CONNECTICUT SOCIETY

OF

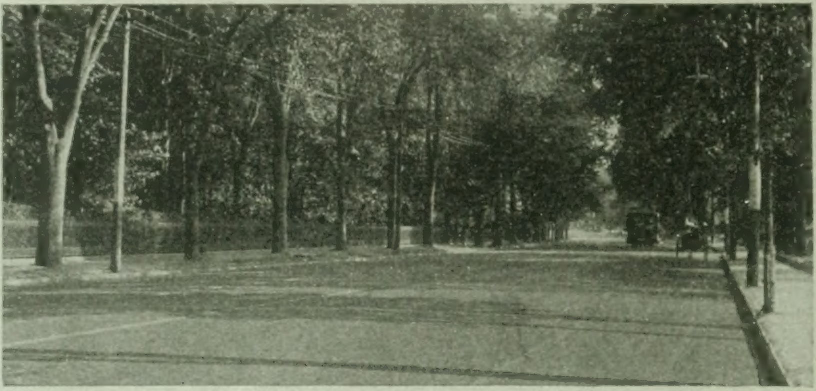
CIVIL ENGINEERS

32

1915/1916

1916

Wood Block Pavement



WEST AVENUE, SOUTH NORWALK, CONN.

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Where new pavements are to be built by assessment on the abutting property the attitude of the property owners has an important bearing on the selection of the type of pavement to be used.

Although Wood Block pavement is by no means the cheapest in its initial cost, it has proved many times to be the pavement on which the property owners most readily agree.

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165 BROADWAY, NEW YORK CITY

Connecticut
Society of Civil Engineers

* * *

Papers and Transactions for 1915

AND

Proceedings

OF THE

Thirty-Second Annual Meeting

AT

NEW HAVEN, FEBRUARY 15 AND 16, 1916

* * *

New Haven
THE TUTTLE, MOREHOUSE & TAYLOR COMPANY
1916

Connecticut Society of Civil Engineers

ORGANIZED AT BRIDGEPORT, JANUARY 15, 1884

◆

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CONTENTS

President Elwell's Address 1

Military Service for Civil Engineers. By Col. William M. Black 6

Recent Advances in the Improvement of Water Supplies. By C.-E. A. Winslow 17

Pollution of New York Harbor and its Remedy. By Kenneth Allen 28

Federal Valuation of Railroads. By H. L. Ripley 49

Discussion 60

Long Distance Telephony. By Edward H. Everit 64

Construction of the Morris Dam Addition to the Waterbury Water Supply. By C. L. Nord 77

River and Harbor Improvement by the United States in the Connecticut District. By G. E. Verrill 95

Proposed Thames River R. R. Bridge at New London. By P. B. Spencer 120

Discussion 124

Design of the New Stratford Avenue Bridge, Bridgeport. By W. Watters Pagon 127

Discussion 131

Influence of the Street, as a Location, upon Street Railway Track Maintenance. By R. C. Cram 136

Discussion 145

Summer Meeting 149

In Memoriam:

- Augustus Jay DuBois 152
- James K. Wilkes 155

Abstract of Proceedings 157

Constitution 176

By-Laws 182

Membership 184

LIST OF EX-PRESIDENTS

WITH DATES OF SERVICE

*B. Hull	1884, 1885
Charles M. Jarvis	1886
Charles E. Chandler	1887
Charles H. Bunce	1888, 1889
*F. Floyd Weld	1890
E. P. Augur	1891, 1892, 1893, 1894
Wm. G. Smith	1895, 1896
Robert A. Cairns	1897, 1898
Edwin D. Graves	1899, 1900
Henry J. Kellogg	1901
Clarence B. Vorce	1902
Frederick L. Ford	1903
John K. Punderford	1904
Albert B. Hill	1905
Charles F. Chase	1906
*Daniel S. Brinsmade	1907
Edward W. Bush	1908
Frederick J. Easterbrook	1909
Shepard B. Palmer	1910
Charles A. Ferry	1911
A. William Sperry	1912
Sheldon E. Minor	1913
George K. Crandall	1914
Charles C. Elwell	1915

* Deceased.

PRESIDENT'S ADDRESS.

The Connecticut Society of Civil Engineers is now celebrating its thirty-second birthday. From a creeping infant, born in 1884 with a membership of only fourteen, it has grown and expanded, and we now find it well developed, with over 400 members. During the past year forty-seven names have been added, and we stand on a much better footing to-day than ever before; but in order to maintain the present high standard, we should have more money, and I therefore urge that the dues be increased from three to four dollars a year.

Following the suggestion which former President Crandall made in his address last winter, viz.: that the society should have more frequent meetings for the purpose of giving the members a better opportunity to get acquainted, we have held smokers at each of the following cities: New Haven, Hartford, New London, New Britain, and Bridgeport. The average attendance at these gatherings has been fifty. No special effort was made to make these meetings instructive, the principal object being to make and renew acquaintances. Everyone was tagged with his name, the tag serving a double purpose, first for identification, and incidentally for the benefit of those who might temporarily forget themselves, or be afraid to go home in the dark.

My suggestion to the incoming president is that the larger cities be encouraged to form local branches of the society, and that each branch hold an occasional smoker or give an entertainment for all members of the society who can attend. Such a movement will relieve the president and secretary of a great amount of work and tend to create a greater interest, and I believe will result in a decided increase in membership.

At these meetings, and more especially at the annual banquets, a half hour should be devoted by the officers to receiving members, particular attention being paid to the younger men. I hope the programme of the future banquets will show just when and where such receptions will be held.

Our summer meeting and clambake was held at North Branford, at the headquarters of the New Haven trap rock quarries, and was a pronounced success. The number attending exceeded our wildest expectations, being the largest gathering of the society on record. A detailed account of this meeting will be found in the printed report of the society proceedings.

The business depression which was so keenly felt by the engineering profession a year ago has been forgotten, and we find everyone overworked. Our best thermometer with which to judge the temperature of business is our railroads. One year ago the sidings of the New York, New Haven and Hartford Railroad Company were crowded with empty cars. There was not siding room available to accommodate such an accumulation of idleness, making it necessary in some cases to appropriate the main tracks for car storage. On one main track a train of empty cars over five miles in length stood for months. At the same time many silent and cold locomotives remained on engine house tracks, telling their sad story of the general business depression.

How different to-day! Yard and side tracks are filled with loaded cars awaiting movement or release, while the engine house forces are working night and day to keep the overworked engines in condition for service.

The state felt the depression last winter to such a degree that salaries were cut, commissions consolidated or abolished, and the cry on all sides was "Keep down the expenses."

The State Highway Department received no appropriation for construction of new highways and must depend entirely upon the appropriation made for repairs, and upon the receipts from automobile licenses, to make improvements in existing roads.

Such sudden changes in business conditions are as unhealthful as the recent changeable weather which is blamed for the sickness and distress which has prevailed this winter. Civil engineers are particularly affected by the fluctuations enumerated, making their work necessarily uneven and undependable.

A step was taken in the right direction by the State Legislature in placing the construction and repairs of trunk line highway bridges under the Highway Commissioner, thereby relieving the towns of much responsibility and placing the great majority of highway bridges under engineering supervision, which has not been universally given before.

Responsibility for accidents on trunk line highways was placed upon the State Highway Department, and it is now possible for a person receiving an injury to bring civil suit against the Highway Commissioner.

An act was also passed allowing the State Highway Commissioner to occupy land necessary for highway purposes prior to extended condemnation proceedings, which is manifestly a wonderful step in advance in securing land for public purposes.

The State Highway Commissioner is very enthusiastic over his experience in using the inmates of the Cheshire Reformatory in the construction of concrete roads. Both from a financial and philanthropic standpoint, this experiment has been highly successful.

The development of a deep water harbor at New London by the United States government, and the construction of a pier 1,000 feet by 200 feet by the State of Connecticut, is practically completed, with the exception of a superstructure in the form of a warehouse and receiving sheds. Should it become necessary to put the pier in service, temporary tracks and sheds could be constructed at short notice and vessels drawing thirty-five feet at mean low water could load and discharge freight.

The biggest problem confronting the engineers of the railroad is the construction of a new bridge across the Thames River at New London. This structure will replace the present one, which was completed in 1888. The 500-foot draw span was celebrated for being the longest in the world, and I believe still holds that title. In all probability its length will never be exceeded, as the roller lift type of bridge now in general favor is not necessarily even half as long as the revolving pattern. You will hear more about the proposed bridge from Mr. Paul Spencer, the resident engineer, who has prepared a paper to be read at to-morrow's meeting.

An interesting question is being solved by the Stratford Avenue Bridge Commission of Bridgeport and will be explained by the resident engineer, Mr. Pagon, in a paper to-morrow.

The engineering profession stands to-day on a much higher plane than ever before; where there was one who could design a bridge, locate a canal or railroad fifty years ago, there are many thousands to-day.

At our smoker held at New Britain recently, Mayor Quigley, in a few words, paid the engineering profession this high compliment: "The engineer works faithfully, accomplishes much, and says very little about it." That is a correct statement. Big things are planned and executed by the engineer, but as an advertiser he is a failure, and for that reason I fear does not occupy the place he deserves among the professions.

The question of licensing civil engineers has been the subject of much discussion and action in other states, but apparently little or nothing has been said or done by this association. Why not take a decided stand now, and see that a bill is presented to our next Legislature, intended to insure the public against those possessing little knowledge of engineering matters, and which shall protect us engineers against incompetents. I do not infer that any who have been practicing engineering for any length of time are incompetent, but the principal value of such a measure should be to discourage young men with little or no technical knowledge from entering a pursuit in competition with those who, by study and practice, have qualified themselves to deal with complicated engineering problems.

Comparatively little has been heard in this country about preparedness, since the civil war, until within the last few months. Now it is being discussed almost continuously. The newspapers are full of it. Measures providing for national defense are being introduced in Congress, the President and his Cabinet show deepest anxiety, while the Military Department is endeavoring to wake everyone up to the necessity of being prepared to defend our country against the possible invasion of a foreign enemy.

This question should appeal to every American—"In what way can I prepare to best serve my country, should trouble of this kind overtake us?" To the civil engineers of Connecticut the answer should be easy: First, strengthen your society organization; study the engineering problems which would naturally have to be solved quickly in time of war; form classes in our large cities where its members may receive instructions from regular army officers on military engineering; members should be encouraged to write papers on such matters as how best to construct defenses for the protection of our coast and cities, etc. Such exercises would not only make us invaluable to our state and nation in time of need, but would make all who take part brighter and more efficient engineers.

I will not dwell longer on this subject, but I hope and trust we may all take advantage of these and any suggestions we receive from the government or army representatives who may be induced to give us detailed instructions and advice. It is not at all impossible that at our next annual meeting many of you may have military titles and possibly be wearing uniforms of the First Connecticut Engineer Corps.

It would be ungrateful of me to close without thanking the members for conferring upon me the highest honor in their power by electing me their president one year ago. I want also to congratulate them upon their selection of my successor, for whom I prophesy an exceedingly prosperous year.

CHARLES C. ELWELL.

MILITARY SERVICE FOR CIVIL ENGINEERS.

By Col. William M. Black, Corps of Engineers, U. S. A.

GENTLEMEN:—I am not going to inflict on you all this manuscript and these extracts, which were prepared for a talk before the engineers of New York. They started about a month ago and wanted one or two of us to come and give them a little talk on this same subject. As a result of that, classes were formed from the engineers of New York City for actual instruction in military engineering, with the idea of fitting them to help their country in time of war. It was announced that there would be held in the engineering building in New York a lecture on a certain evening in the week, and the first one was to be last evening. Three of the captains on duty in New York were to deliver these lectures; they had a hall which would hold 500 people; some 1,400 people came. So that not only did the man who was to deliver the lecture last evening have to speak, but the others had to go and hold overflow meetings. I asked my assistant, who acted at one of these overflow gatherings, how he got along. He said, "I don't know just how I got along. I know I spoke for two hours; there were a great many men standing up in the rear of the hall when I started; and they were still there when I stopped."

This is a very large subject and a very important one. There is much of interest that I could tell you. Mr. Elwell asked how much time it would take. I told him it would take all the time there is; but I am not going to inflict it all on you this afternoon; only just a little. If I can, I want to give you some ideas that will enable you to do what every patriotic American wants to do, to make himself ready so that when the hour of trial comes he can do his part effectively for the assistance of his country. Everybody in America, I am sure, will be willing to do all he can, but that is not all that is required. Effective work is required from everyone. That means preparation such as we have never had. Now, those of us who are older among the engineers know, when we think back twenty, thirty or forty years, what an awful lot of things we used to know that aren't so. I know I knew a great many more things thirty years ago than I do now. In other words we, all of us, have learned from experience (and here at New Haven it is not necessary for me to say it) and know that the real value of learning history is to gain the experience of other men so that we may be taught by the lessons that they received, as well as by our own. And, therefore, in starting what I have to say to you this afternoon I thought I would just read a few extracts from the experiences of men whose memories you reverence; showing that this is not a new question; that the awakening of the people of the United States to the necessity for preparation is simply tardy; and that since the very foundation of our government those who held the reins of government and who were responsible for affairs had the necessity for this thrust upon them. Even at the risk of taking up some time I would like to read just a few extracts. (Reads extracts from messages of the early Presidents.)

This question of the obligation to universal military service is not a new one. It was an obligation that was thoroughly understood in the days of the colonies and in the early days of the republic. It has only been of late years that men have thought that military service was not an obligation of citizenship. In the early days our fathers knew it was and responded to it.

So I could go right through; almost every President has something to say on this question; and yet it is only within a year that our people have begun to awaken.

We are a democracy; and we believe in it. We believe in the principle that every man must have his chance. But do we always realize that being a democracy, each individual citizen has obligations that he might not have if he were a member of an autocracy or subject of one? Do we always realize that it is the people themselves who must fix the policy of the United States? who must declare how much of its income can be spent for this object or that object. We are sometimes inclined to put the blame on Congress for not having done this or that. Gentlemen, my duties have brought me into very close relationship with Congress for twenty years or more; and I can assure you that the members of Congress are, in the very strongest sense, the servants of their constituents. There is nothing originated in Congress except what is forced upon it by the will of the people.

Congress will do infallibly what the people want it to do. And so it is up to the individual citizen of our country to think for himself, and insist that his representative in Congress truly represents the will of the people. And if it is our will that our country shall be maintained, and if it is our belief that it is in danger of being assaulted, then it is the duty of each individual citizen to see to it that the measures that are necessary for our protection shall be carried out. Congress will do it if the people do their share. However, that is all preliminary.

Now, I take it that you gentlemen are truly interested in knowing how to prepare yourselves so as to best serve your country, and serve it effectively, should your services be needed. Being engineers you are of the class which has received the very best preliminary training for field duty in the defence of the country. A very large proportion of your training, and all of your technical education, is directly in the line of that kind of duty; much more so than that of men engaged in other civil pursuits. You are accustomed to handling men; you are accustomed to working through other men; you have had it impressed upon you in your practice that if any man at the head of a large organization tries to do it all himself he will fail; that he must work through assistants. Then, again, you are accustomed, many of you, to live in the field; to care for men in the field, and to direct men in the field. All of these are most essential qualities for a soldier. So that what you need most of all is that preparation which will enable you to take a soldier's viewpoint of the kind of engineering work that you will have to undertake in time of war. That viewpoint differs somewhat from that of a civil engineer. I will try to point out to you in just a few words, if I can, the kind of duty, and how it differs from similar duties of the civil engineer.

For instance, Army Regulation No. 1,493 gives the duties of the corps of engineers as follows:

> 1493. The duties of the Corps of Engineers comprise reconnoitering and surveying for military purposes, including the laying out of camps; selection of sites and formation of plans and estimates for military defenses; construction and repair of fortifications and their accessories; the supervision of the location of all buildings in or within one mile of any fortification; the installation of electric power plants and electric power cable connected with seacoast batteries, and furnishing the necessary electrical supplies connected therewith; planning and superintending of defensive or offensive works of troops in the field; examination of routes of communications for supplies and for military movements; construction and repair of military roads, railroads, and bridges; military

demolitions; execution of river and harbor improvements assigned to it; and such other duties as the President or Congress may order. * * *

In time of war, within the theatre of operations, it has charge of the location, design, and construction of wharves, piers, landings, storehouses, hospitals and other structures of general interest, and of the construction, maintenance, and repair of roads, ferries, bridges, and incidental structures; and of the construction, maintenance, and operation of railroads under military control, including the construction and operation of armored trains.

That is the outline of the duties of the corps of engineers. As a matter of fact, gentlemen, if there is anything that turns up in the line of military duty that is particularly difficult or particularly unpleasant to do, you may be dead sure that the engineer will be called upon to do it. It is always so, no matter where you are. And really one of the troubles that we have in training our engineers now is that they are so exceedingly useful that they are called off for all sorts of duties, and we cannot get them for the drills that they should have. They are a very handy kind of people to have around. In time of war you will find that the engineer will be called upon to do anything and everything. And there comes in one of the differences between military and civil practice. The man who is on duty with troops in the field and wears a castle on his coat collar, is supposed by all the other officers to know all about military engineering. It won't do a particle of good to say that you are a bridge expert, or that you are a sanitary engineer, or any other kind of an engineer. You are an engineer; and if there is anything in the wide world that comes up that has any possible relation to·engineering, you are called on to do it. So that with troops at the front no man can be a specialist; he must be able to turn his hand to anything, and make a stab at it anyhow. Naturally it may not sometimes be a very good effort. Results are what is wanted, and the question of cost is not looked at; that is, in service with troops in the field. So that any man who desires for himself that kind of service must have knowledge of everything in engineering. What he doesn't know he must pretend to know; and he must do the work anyhow.

In time of war there are two fundamental classes of service for the military engineer: one is termed the service of the interior; and the other the service of the theater of operations. The service of the interior includes all branches of civil engineering, but not in the face of an enemy. That service may well employ, and will have to employ, the civil engineers of the country who, from age or other reasons, cannot go to the front. The service of the theater of operations is divided into two classes: the zone of the advance, and the zone of the line of communications. The zone of the advance means operations directly in the face of the enemy. In that zone no civilian labor whatever is employed, because a man's life is threatened at every moment. Usually soldiers must do everything. In the zone of the line of communications, which extends from the advance base up to the line of battle itself, there is a limited amount of civilian labor that can be employed. It is in that zone that a large amount of semi-permanent repairs have to be made to bridges and highways and railroads. There in that zone the military have control of the railroads. Under the regulations, if there is a railroad running from the advance post, it is put in charge of an engineer officer who is termed the "Director of Railways." He is directed to maintain the civil staff of the railroad just as far as they are willing to stay with it and have them operate the road, only he must have it operated with a view to military necessity. And that is quite a different matter from its usual operation in normal times, which I will not go into now. At the extreme front the repairs to the road are made by the army engineers and the engineer enlisted men. As you know in reading accounts of the present war, the lines of operation follow the lines of communication, either the railroads or the great rivers, and the same railroad may be torn up and rebuilt four or five times in a year. It was said some time ago that one of the German generals deceived the Russians utterly by making use of his railroad at night when the aeroplane observers could not see, loading a lot of troops on the trains and carrying them to the rear; then the following day, when the aeroplanes were up, these troops would be marched forward; so that he created the impression in the minds of the Russians that he was receiving enormous reinforcements. That shows how close to the trenches the rail head was carried, and is carried in times of war.

In the present constitution of our service we have a regular army which is so small as to be almost an absurdity, I am sorry to say. There couldn't be better men; there couldn't be better trained or more loyal officers than we have, but they would be utterly lost in case of trouble. And when we think that to-day all of our available army practically is on the Texas frontier; and that there is no infantry, not a single infantry soldier, nearer New

York City than Plattsburg barracks on Lake Champlain, because the infantry posts are ungarrisoned; and that in the great fortifications surrounding the city of New York one-half of their already too small garrisons has been taken away in order to garrison points that cannot be reached safely in time of war, the Hawaiian Islands, the Canal Zone, and the Philippines, you can understand, what the regular army knows, that if we were attacked to-day we could make no defence whatever,—we are utterly helpless in the face of any enemy larger than Hayti. I think we can stand Hayti.

Now, we have 248 officers of engineers in our corps, and we have 1,974 enlisted men. In our country the proportion of engineers per thousand of infantry is one officer and thirty enlisted men to each thousand of infantry, and one officer and thirty-eight enlisted men to each thousand of cavalry. That proportion is about three per cent for an army of 500,000 men, which would be just about one-half of what we would have to have under arms within not more than a month, probably not more than three weeks, from the time that war was declared against us; then would be required on the same ratio 500 officers and 17,500 enlisted men. Five hundred thousand men is only a drop in the bucket when we think of the length of our line. I am saying this not from mere theory. A part of my duties for the past eighteen months has been the study of plans for our defence. And these military studies are exactly the same as engineering studies. For instance, in studying this, the first thing we study is what an enemy would probably want to do, what objective he would take; and then, if they want to do this thing how are they going to do it; where they will land, and how they will land. And then the answer is worked out—what can we do to prevent them; providing a line here or here, in such numbers, and so forth. Five hundred thousand men for the defence of the Atlantic coast line is altogether too small, when you consider the length of that coast line, and when you consider the number of men that can be brought against us by a big, first-class power. Three per cent is too small for the proportion of engineer troops. We would have to have more than 500 officers and 17,500 enlisted men. Everybody can readily understand that these 500 officers, in addition to what we have, must be engineers by training; but they do not always understand that in this 17,500 soldiers we must have 1,460 sergeants, of the grade of the junior engineers we have in the civil service, and 1,950 corporals. You can readily see the need of trained engineers. Now, the first proportion I have given you is three per cent. To-day Germany has six per cent. So that if we were to get on to the German basis of efficiency (and the German army is organized on that basis), instead of having a proportion of three per cent we would have to have six per cent; and these figures must be doubled. Where are the engineers to come from? It is from you, gentlemen, that the Government must get these men. And if you are ordered out on duty with troops in the field, with the lack of training you have now, you will find yourselves sadly at sea. It would be simply a sacrifice of your own lives, of the lives of the enlisted men under your direct orders, and very possibly of the lives of the army, because on the work of the engineer depends the safety and the wellbeing of the entire army.

I will run rapidly over now some of the duties that would fall to your lot. Take the subject of reconnoitering and surveying for a map to be used in the field. The scale should not be larger than one inch to the mile. Otherwise it makes the map cumbrous. On that scale the principal accidents to the ground can be clearly shown. These military maps must show the character of the roads, the grades; whether improved or soft; whether natural roads, gravel or clay or improved roads; the bridges and their character; fords; wooded areas. These things must be given on the map. Absolute accuracy is not necessary in this kind of work. A three per cent error is permissible, because you can readily see if you are trying to find out how far you can go in a day's march the difference of an eighth or a quarter of a mile will make no difference whatever. And the same margin in range will make very little difference; because you take your map range simply to show you the first range at which to set your sights on the gun; after that you get it by observation.

Then if you are reconnoitering or making a map for a position to be occupied you would use a scale of three inches or six inches to the mile. Here the contours should be placed; all the wooded areas shown; obstacles for the defence, and obstacles to advance. For instruments you would have, of course, the prismatic or other compass, hand level; clinometer; odometer. Five per cent of error in distance is allowed there. The object is to give all the features of military value. With regard to camps—they must be located with respect to the roads, and with respect to the character of the soil. At a point at Chickamauga, for example, the ground was absolutely hard; it looked to be in every respect an ideal site for a camp. Yet when the soil was examined there were found great cracks traversing it in every direction. So that if a heavy rain came it would be nearly an impassable bog. All those questions must be looked into in the selection of camp sites: the water supply; fuel, and forage; all the requirements of sanitation.

Take the subject of military defences, which it is the duty of the engineer not only to build but also to locate in the first place. The object of works of defence is simply to enable one man to do the work of three or four; it makes effective the fire of a smaller number of men. They may be of many different characters. We have read how the supposedly very strong fortifications in Belgium were knocked to pieces in a very few days by the German artillery fire. But there was nothing really surprising about that; because at the time these fortifications, permanent works, were built, the guns that were placed in them were a great deal heavier and had a longer range than any guns that at that time were built to be moved with an army; but the science of engineering advanced, and the science of gunmaking advanced, so that instead of having to meet conditions existing at the time the forts were built and equipped, the Germans brought up heavier guns of longer range that those in the fortifications. The result was that the Germans could locate their guns where they pleased, could locate their target with precision, while it was difficult for those in the fortifications to locate the guns of the attacking party, and the fortifications were consequently soon knocked to pieces. This does not show that fortifications are useless by any manner of means, as is shown by the fact that to-day the whole front of both armies, French and German, is one long line of fortifications.

You must know how to use the men and materials at hand; how to place them. Your position on the defence is one of very great importance. You remember, those of you who are older, the terrible slaughter in what was termed the "peach orchard" at Gettysburg where the general in command moved his troops to a point where his flanks were exposed, and his army was smashed. So in the selection of positions you have to be able to judge whether a certain position is properly supported from assaults on the flank and in the rear; you must be able to tell whether it would be best to have the troops on the slope toward the enemy; on the front of the hill instead of the military crest; or even behind the crest. These things must be determined and determined quickly. All these things come in under the making of fortifications. If anybody had time to draw up specifications for these works there isn't a man here who couldn't build them, and say it was the easiest thing in the world; but he has to be plan and specification and boss himself. There is nothing reduced to writing; he must do it all; so that this type of education is necessary.

I might say a great deal about fortifications. It is a subject of absorbing interest. The science is one of gradual development; it has continually advanced; starting with certain crude forms, coming up to the forms of to-day. And the history of fortifications, besides being pleasing, is a most valuable one for any engineer to study because, knowing what has been done in the past to resist attack, he is better prepared to take the next steps required in the future by some new means adopted for the attack.

And there are many other things you have to know. How large a position you can occupy. You have so many troops and the flanks must be in position resting on strong, natural obstructions which cannot be easily turned. One of the things that you must know and be able to judge is how long a line can be held by the command with which you serve. That is a question of judgment. The best rule I ever saw was that laid down by General Frank V. Greene. He said, for the defence, there must be at least three men to the yard, and for the offence at least seven. At the present time in France the defence has seven to ten, and the offence as high as twenty men to the yard.

Take the subject of military mining—the whole work must be absolutely concealed. The enemy must not have the slightest inkling that you are even building a mine.

Take the process of repairing railroad bridges. Quite recently one of the Austrian engineers, serving on the front against Russia, where they have been having pretty long movements, in speaking of the repair of bridges said: "It is a very simple thing indeed for any man to repair a bridge. There is no trouble at all to get your workmen, and the material to make the repairs; but it is the most difficult thing in the world to get them built in the shortest time possible." For all of the business at the front, time is the main consideration. You have to take whatever materials you can get at hand and you have to get things in place in the shortest possible time. The operation of crossing water in the face of heavy fire is the most ticklish operation we have in war, probably; and the success or failure of it will depend on the engineers. And their success or failure will depend not only on the knowledge of the engineer in charge but on the training that he has been able to give to his men, so that the whole thing will move along like clockwork, not a lost motion anywhere.

The question of demolitions is simple.

So that, for a military engineer, the requisites are that, first of all, he shall be a soldier. That is, enough of a soldier to understand the military necessity or military needs of any situation. Then he must have what we hope all engineers have, energy, resourcefulness and good judgment. The military engineer cannot select his men; he cannot try out an assistant, and if he doesn't like him discharge him. He must take the material that is right there, be it welcome or unwelcome, and he has to make the very most of it; and to get the very best possible work out of it. In addition to all this, as I told you, military engineers must work right under the fire of the enemy; they are armed and disciplined just as the infantry, and are capable of taking their place in line of battle. Possibly you have seen in the *Illustrated London News* last week, some pictures of military engineers, emerging from the trenches prepared to go out in front of their lines for the unpleasant work of putting up barbed wire; or worse yet, going to cut out the enemy's barbed wire. If you just look at the figures and do not look at the inscription underneath you will think that you are looking at men at arms of the 15th or 16th century, because the helmet and breastplate, and a good deal of the other paraphernalia of war in those days is seen there. Worse still, perhaps, is the work of the men who are doing the military mining, because there they must work right up under the enemy with a perfect knowledge that he is listening for them, and that if he should hear he would probably countermine and destroy them. That is not pleasant work.

For the handling of men you must have a knowledge of paper work. No large operation can be run or is run without a certain amount of paper work. It is so in the army, only a little more so, because the men are coming and going through death or wounds.

Now, to come right down to the point of this thing—what can you do? There are several things that you can do. One thing, of course, is to join camps that are being established at Plattsburg, and one of the things that will come to you, one of the greatest advantages you can get from the service through one summer camp, will be the knowledge of how little you know. You will get benefit physically and you will learn something, but you will have a little insight into how much more there is to it. So that attendance at summer camp I should very highly recommend. I understand that General Wood has had the matter in contemplation of trying to establish a distinctly engineering camp for men who have been through one or two courses of training at the ordinary camp. This soldier training must come first. Another very good way to get it, and a most excellent way, is to affiliate yourselves with the National Guard. Connecticut has no organized body of engineers at all. New York, Pennsylvania and Ohio have such bodies, but outside of those states I now recall no other.

Then if you want to read in advance it won't do you any harm to do it; and there are a number of little books you can get. (Gives list of books, publishers, etc.):

Infantry Drill Regulation 1911. Price, 60 cents. Government Printing Office.

Field Service Regulations 1914. Price, 60 cents. Government Printing Office.

Notes on Field Fortification, Army Field Engineer School. Price, 30 cents. Book Department Army Service Schools, Fort Leavenworth, Kans.

Engineer Field Manual. Price $1.00. Government Printing Office.

Military Topography for Mobile Forces. Sherril. Second edition. Price, $2.25. Banta Publishing Co., Menasha, Wis.

Studies in Minor Tactics. Price, 50 cents. Army Service Schools, Fort Leavenworth, Kans.

The Service of Coast Artillery, Ames & Ward. Price, $3.50. Goodenough & Woglom, 122 Nassau Street, New York City.

If any of us in the regular service can be of assistance to you be very sure that we will be glad to do all that is in our power in order that, if this country of ours should ever be assailed, we can make the best account of ourselves that is possible.

RECENT ADVANCES IN THE IMPROVEMENT OF WATER SUPPLIES.

By C.-E. A. Winslow, Anna M. R. Lauder Professor of Public Health, Yale Medical School.

Some one once said that, in regard to public water supplies, innocence was to be preferred to repentance, meaning that a water of pristine purity was better than one which had been polluted and then artificially purified. Sanitarians, however, have come to be profound sceptics in regard to the original purity of surface waters. They are convinced that such waters, like those who drink them, lie under the curse of original sin; and they are inclined to demand as pure a supply as possible, purged by the penance of purification before it is consumed.

Innumerable outbreaks of water-borne disease, of which the New Haven epidemic of 1901 at once comes to mind, have taught that no running streams, and but few natural lakes, can be relied upon to furnish at all times a pure and wholesome water. Heavy rains and melting snows, particularly in the early spring, wash into such waters all sorts of contaminating material from the banks. There are very few watersheds which do not contribute a certain proportion of human pollution from overflowing privy vaults and cesspools, and once in so often, among the contributors of this pollution, there will be a typhoid fever case or a carrier and an epidemic of greater or less proportions will result. One or two typhoid carriers are to be found in every thousand of a normal American population, and it is simply a question of the law of chances when any surface supply which receives fresh surface wash will become a menace to those who consume it. Control of a watershed may of course greatly reduce the danger, but unless policing is very thorough it cannot prevent occasional chance pollution by campers or by tramps.

There are four principal methods by which surface water supplies may be made safe for drinking,—storage, slow sand filtration, mechanical filtration and disinfection; and I purpose to dwell very briefly on each of them in turn, calling your attention to recent advances in our knowledge of the efficacy of each and to certain modifications of method which have resulted from recent investigations.

Storage is a real and an efficient process of purification under certain conditions. Typhoid bacilli and other disease germs are adapted to life in the rich fluids of the human body, and in water they die off in proportion as the time of their sojourn in the unfavorable medium is prolonged. Laboratory experiments and epidemiological experience indicate that even water which has been considerably polluted with typhoid excreta will free itself from appreciable numbers of disease germs in a storage of three or four weeks. Lake waters are in general, therefore, far safer than river waters as sources of public water supplies.

The difficulty with purification by storage is that the potential or ideal storage capacity of a lake or reservoir is seldom realized, and that the actual storage of a given volume of water is profoundly modified by the changing conditions of wind and water movement. The danger of short-circuiting, or the rapid passage of water currents from one point to another in a lake, was admirably illustrated by the experience of the city of Auburn, N. Y., which I had recently the opportunity of studying in some detail. Auburn is a city of some 35,000 inhabitants, situated at the northern or outlet end of Lake Owasco, from which it derives its public water supply. The lake is a long narrow "finger lake," as they are called in central New York, about ten miles long and a mile wide. At its southern end the lake is fed by the Owasco Inlet, into which empties a small stream, Mill Creek, along the banks of which is the village of Moravia. The largest single source of pollution of Mill Creek was, until recently, a four-inch sewer from a high school having some 300 pupils.

Moravia suffered from an epidemic of some twenty cases of typhoid fever in the autumn of 1907, at least three cases occurring among pupils of the high school, two of whom returned as convalescents (and perhaps as carriers) in the spring. During the winter the lake was frozen, but in the middle of March, 1908, there was a heavy thaw, the ice broke up and the level of the lake rose rapidly. At the same time a great increase was apparent in the bacterial count of the Auburn water; and in April a sharp epidemic of thirty-four cases of typhoid fever broke out in Auburn. The outbreak was distributed evenly over the city and had every characteristic of a water epidemic. Since no other cases of typhoid fever than those at Moravia were known to have polluted the waters tributary to Owasco Lake, the chain of evidence pointing to Moravia village as the source of the Auburn typhoid was a strong one. The high school was selected for prosecution as the principal offender and an indictment was found against the trustees for maintaining a public nuisance on three counts which charged them with "offending public decency," "annoying, injuring and endangering the comfort, repose, health or safety" of a considerable number of persons and rendering "a considerable number of persons insecure in life or the use of property."

The only difficulty in the path of the prosecution lay in the question whether virulent typhoid germs could possibly survive a trip down a lake ten miles long with only a negligible current. All of us who were concerned at first questioned whether such a survival was possible, for the length of Lake Owasco seemed to furnish an ideal opportunity for the purifying effects of storage. A remarkable study of the relation between wind and water movement in the lake, conducted by J. Walter Ackerman, the engineer of the Auburn Water Board, made it clear, however, that the lake was by no means an effective barrier (Proceedings, American Water Works Association, 1913, p. 291). He found by float measurements that the upper five feet of water in the lake was moved along by the wind at a velocity ranging from over 3 per cent of the velocity of the wind movement for a wind velocity of five miles per hour to 1 per cent of the wind movement for a wind velocity of thirty miles per hour, and he showed that at the time of the break-up in the early spring of 1908 there were several periods of south winds of velocity and duration sufficient to move the surface waters of Lake Owasco from inlet to outlet in two or three days. As a result, a criminal conviction was obtained against the school trustees on the second of the three counts cited above.

Such possibilities as this make it reasonably clear that there are few lakes or storage reservoirs, in the state of Connecticut at least, which can be relied upon to remove at all times pollution which may be washed in from their shores. Unless the watershed is owned by the city or water company, and thoroughly patrolled, one of the three remaining methods of purification, all of which are efficient and reliable, should be added as a final safeguard.

Slow sand filtration, or the passage of the water through beds of properly selected sand at a rate of 1 to 5 million gallons per acre, is the oldest and best established of these procedures. It yields admirable results, and the cost of filtration, including interest charges and operation, is usually in the neighborhood of ten dollars per million gallons. The practice of slow sand filtration has been fairly well standardized, although there is a recent tendency to prepare the water, if it is at all turbid, for filtration by sedimentation or straining through pre-filters and to increase the rate on the sand filters themselves. Two million gallons per acre used to be the usual rate, but four or five million is now more common, and some plants with very clear waters are raising the figure to ten million gallons per acre per day. Beds are usually .5 to 1.0 acre in area and are made up of three feet or more of sand of an effective size of about .3 mm. over one foot of gravel. The interesting problem in connection with sand filters at present is the most economical method of washing the sand, as it becomes clogged by the accumulation of suspended solids from the water and by the growth of microörganisms in its surface layers. Originally the sand scraped from the surface of the beds was carried in wheelbarrows to the sand washers; and, long after the practice of shoveling the sand into portable ejectors and moving it to the washers by hydraulic power had become established, it was still the custom to replace the sand by hand. The experience of the Washington filtration plant where, in 1909, a hydraulic method of replacing the sand proved eminently successful, soon led to the abandonment of the older method. A year later, the Nichols washer was introduced, a portable machine which is moved into the bed and washes the sand fed into it and returns it immediately. The most elaborate form of apparatus is the Blaisdell machine, a water-tight chamber containing the washing machinery, which travels over the filter on a traveling crane. The chamber is lowered and the sand over the area covered is washed within it in situ. The Blaisdell machine, which is in operation at Wilmington, Del., is costly and requires highly skilled operation. The Nichols washer, however, has reduced the cost of cleaning and replacing sand at Albany, N. Y., to about half what it was when the sand was removed to ordinary washers by the ejector method and replaced by hand, and the Washington system of complete hydraulic handling with ordinary washers has yielded excellent results at a low cost (Journal of the American Waterworks Association, II, 596).

For waters having a considerable turbidity, mechanical filters are used, operating at a rate of 100 to 150 million gallons per acre and depending for their efficiency on an artificial filtering layer of hydrate of alumina or some similar chemical; and even with fairly clear waters the cost of treatment by this method is often less than that involved in slow sand filtration. The line between slow sand and mechanical filters is much less sharp than it was ten years ago. While slow sand filters are now operated at more rapid rates and cleaned by mechanical methods, mechanical filter units have become larger and their washing appliances have been simplified. The original mechanical filters were tubs cleaned by reversing the flow of water while the sand was stirred by revolving rakes. Then it was found that if the wash water were admitted at a pressure giving 10 to 15 inches vertical rise per minute, the sand could be sufficiently agitated without mechanical means by forcing in air along with the water at a rate of 2 to 5 cubic feet per square foot of filter area per minute. Finally the wash water was applied under still higher pressure so as to give a vertical rise in the bed of 24 to 30 inches per minute, which is sufficient to agitate the sand without either rakes or air. The average size of bed in thirty-four mechanical filter plants recently tabulated by Nicholas S. Hill, Jr., was 579 square feet, with a filtering capacity of 1,600,000 gallons per day, or 125 million gallons per acre. The average depth of the sand was thirty-one inches, over ten inches of gravel and the average effective size of sand .43 mm. The precipitation of a certain proportion of suspended solids in coagulating basins almost always precedes mechanical filtration.

As the method of cleaning sand is the most important factor in efficient operation of slow sand filters, the cost of the coagulant used to precipitate the suspended matter and produce the filtering layer on top of the sand is the chief element in the operating cost of mechanical filters. Here, as in so many other fields, the difficult conditions incident to the European War have exerted the pressure of necessity upon American invention and rapid advances have been made, and are making, in cheapening the cost of the necessary chemicals.

The most important step in this direction has been taken by Mr. C. P. Hoover, chemist of the filtration plant at Columbus, Ohio; and on a recent visit to this plant I was impressed as never before by the fact that a modern large scale water treatment plant is a chemical industry of no mean magnitude. Mr. Hoover's principal achievement, so far, has been the development of a new method for making sulphate of alumina for coagulation (Journal, American Waterworks Association, II, 693). The usual method of making this chemical involves boiling up a southern clay, bauxite, with sulphuric acid, which changes the hydrate of alumina into the sulphate, filtration to separate silica present, concentration of the solution by boiling, crystallization of the alum cake, pulverization, packing and shipment to the filter plant where the alum is dissolved as needed. Mr. Hoover has discovered that the original solution obtained by treating bauxite with acid is entirely suitable for coagulation and that the silica present is actually an advantage rather than a disadvantage because its suspended particles form a matrix which helps to start coagulation. At Columbus, therefore, he is making his own sulphate of alumina by boiling bauxite and sulphuric acid in lead-lined tanks until a basic solution is obtained, diluting the solution and measuring it as needed directly into his solution tanks, thus eliminating the process of filtration, concentration, crystallization, grinding and redissolving. Other interesting experiments are in progress at Columbus on the preparation of sulphuric acid, and for large plants these procedures promise material reductions in operating cost.

In connection with these chemical problems of mechanical filtration a word should be said as to some recent advances in methods for the softening of hard waters. The usual procedure, as you are aware, depends on the removal of temporary hardness (bicarbonates of calcium, magnesium and iron) by precipitation with lime and the removal of permanent hardness (sulphates, chlorids and nitrates) by the addition of soda ash. As a rule, waters are not softened to a point below fifty parts of total hardness per million, as the attempt to go below this figure is likely to lead to an excess of reagents and a caustic water.

For laundry and domestic purposes, however, a lower hardness is often desirable and the new process of softening by the use of permutit or refinite promises to meet a real need.

Permutit is an artificial zeolite, a complex hydrated sodium silicate, which has the power of substituting for its sodium the calcium and magnesium present in water which comes in contact with it. The water to be softened is simply allowed to run through a filter bed of permutit and its calcium and magnesium are absorbed by the permutit, the acid radicles in the water being, of course, changed to sodium salts. When the sodium content of the permutit has been reduced to an economic limit it can be regenerated by passing through it a solution of common salt, which reconverts the calcium and magnesium permutit to sodium permutit. Refinite is a natural zeolite produced in the Middle West, which, according to the experiments of Professor Edward Bartow of the University of Illinois, produces the same results as the artificial permutit. The cost of the process is high on account of the expense of salt regeneration; the water to be softened must be clear or the filter will clog; but the simplicity and automatic nature of the process, and the fact that it is the only method of treatment which will yield a zero hardness, gives it an important value for domestic and industrial plants where a perfectly soft water is desired.

While slow sand and mechanical filtration are efficient and reliable methods of securing a safe water supply they do involve an appreciable expense. The expense is small in comparison with even a remote risk of a typhoid epidemic. Ten dollars a million gallons, which would be an average figure for slow sand filtration, and above the average for mechanical filtration, means about one-tenth of a cent a day per person, a small sum to pay for insurance against water-borne disease. In the fourth general method of purifying water, by disinfection, we have a vastly cheaper method of securing a very high degree of safety, if not absolute protection.

Disinfection of water as a routine procedure by the use of calcium hypochlorite was first practised at the Bubbly Creek plant of the Chicago stock yards in 1908 and on a municipal scale in the same year at Jersey City, N. J., the engineer primarily responsible for this important development being Mr. George A. Johnson. In both these cases I gave testimony on behalf of the municipal authorities in favor of the contention that the hypochlorite treatment did not give assurance of fulfilling all the sanitary requirements of the particular problem; and later developments have not tended to alter my opinion. Yet it is certainly true that the Chicago plant, under the able management of Mr. Charles A. Jennings, has yielded an effluent of remarkably good quality and that the Jersey City plant has vastly improved the quality of the Boonton reservoir water. Disinfection does not, of course, affect the physical characteristics of the water,* and with a water of varying organic content it is difficult to adjust the quantity of hypochlorite so as to secure efficient disinfection at all times without producing tastes and odors in the water, due to an excess of the reagent. The introduction of this process has, nevertheless, been rapid and very generally successful during the past few years. Mr. Longley, chairman of the Committee on Water Supplies of the Sanitary Engineering Section of the American Public Health Association, reports the installation of disinfecting apparatus for treating 100 million gallons of water per day in 1909, 450 million gallons in 1910, 320 million gallons in 1911, 710 million gallons in 1912, 70 million gallons in 1913 and 265 million gallons in 1914 (American Journal of Public Health, V, 918); and the results of hypochlorite disinfection in the reduction of typhoid death rates have in scores of cities proved most gratifying. As an emergency procedure in the face of a typhoid epidemic and as an adjunct to one of the other methods, storage or filtration, the value of disinfection cannot be overestimated.

During the past two or three years a further advance has been made in the development of processes for the disinfection of water by the use of liquid chlorine instead of a solution of hypochlorite. Liquid chlorine treatment has great advantages in the simplicity and more automatic operation of the apparatus, in the freedom from odors about the plant, in the more rapid absorption of gas by the water, in the absence of a loss of chlorine through deterioration of bleach and in other ways, in the ease and accuracy with which the rate of application can be regulated, and in the lower cost. The cost of hypochlorite treatment is very small, averaging about 25 cents per million gallons, but with liquid chlorine it may be reduced to an even smaller figure. Mr. M. F. Tiernan of New York City informs me that at Bubbly Creek (where the highly polluted water makes the cost very high), the hypochlorite reduced the cost for labor and materials from $6.00 to $1.50 per million gallons; while at New Haven the cost of liquid chlorine for treating a raw water of fairly good quality averages 20 cents per million gallons, and at Trenton, N. J., the cost of chlorine for treating a filtered water was 15.8 cents per million gallons. With the present high price of bleach, Mr. Newlands estimates that an equivalent amount of available chlorine in the form of hypochlorite costs more than twice as much as in the form of liquid chlorine. The New York State Department of Health has an emergency liquid chlorine plant which is sent to cities where water-borne typhoid is prevalent. In two such cities, Lockport and North Tonawanda, and in several smaller places, such outbreaks have been instantly cut short by the installation of this plant. At North Tonawanda the cost of the apparatus and its installation was $300 and the daily cost of chlorine $1 a day for a population of 12,000. With such cheap means of purification within reach there is no longer the least excuse for any community continuing to use untreated surface water of a character subject to the slightest suspicion.

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* Except as regards color. It has been noticed by the New Haven Water Company that in some cases liquid chlorine treatment of water causes a noticeable reduction in color. In other cases there was no noticeable effect. At Hartford, Mr. J. A. Newlands has noticed a color reduction of about 20 per cent by the liquid chlorine treatment.

Chapter 306 of the Public Acts of the Connecticut Legislature for 1915 gives to the State Board of Health much needed powers of supervision over the public water supplies of the state. This Act reads as follows:

AN ACT CONCERNING THE POLLUTION OF WATER SUPPLIES.

Be it enacted by the Senate and House of Representatives in General Assembly convened:

SECTION 1. The state board of health shall have supervision over all matters concerning the purity of any source of water or ice supply used by any municipality, public institution, or water or ice company for obtaining water or ice. The term "source of water or ice supply" shall include all springs, streams, water courses, brooks, rivers, lakes, ponds, wells, or underground waters from which water or ice is taken, and all springs, streams, water courses, brooks, rivers, lakes, ponds, wells, or underground waters tributary thereto and all lands drained by such springs, streams, water courses, brooks, rivers, lakes, ponds, wells, or underground waters.

SEC. 2. Every person, firm, or corporation supplying water to the public at the time of the passage of this act shall, on request, furnish the state board of health with all reasonable information regarding its water works and the source from which its supply of water is derived. No system of water supply owned or used by such municipal or private corporation or individual shall hereafter be constructed until the plans therefor have been submitted to and approved by said board.

SEC. 3. The state board of health may, and, upon complaint, shall, investigate any source of water or ice supply from which water or ice used by the public is obtained, and if it finds that such source of water or ice supply is contaminated or rendered impure, it shall notify any person or corporation causing such contamination, of its findings, and after hearing, shall make such orders as may be necessary to prevent the contamination thereof.

SEC. 4. The state board of health may employ agents, engineers, and assistants to carry out the provisions of this act at an expense not exceeding such sums as may be approved by the state board of control.

SEC. 5. Any person or corporation aggrieved by any order of the state board of health, made under the provisions of this act, may appeal within thirty days to the superior court for the county in which the source of the water or ice supply is located. If such source is located in more than one county the appeal shall be taken to the superior court for that county containing the part of such source nearest the mouth of the stream or river forming the main portion of the source of supply. Such appeal shall be by a petition in writing. An attested copy of such petition shall be served on the state board of health at least twelve days before the return day of such petition, and the appellant shall give notice to all parties in interest by publication in a newspaper or as may be ordered by the court to which such appeal may be brought or by any judge of such court when such court is not in session. Such court may hear such appeal, by itself or a committee, and shall proceed thereon in the same manner as upon complaints for equitable relief, and may make such order, including taxation of costs, as it may find proper.

SEC. 6. Any order of the state board of health issued under the provisions of this act to any person or corporation shall specify the time within which such person or corporation shall comply with the terms thereof. If such person or corporation shall fail to comply with the terms of such order and no appeal shall be taken therefrom, the county health officer of such county shall bring a complaint against such person or corporation to the superior court of such county.

SEC. 7. Any person or corporation violating any provision of this act, or any order of the state board of health made under the provisions hereof, shall be fined not more than one hundred dollars.

Approved, May 20, 1915.

If the power to "make such orders as may be necessary to prevent the contamination" of sources of water supply is worked out in practise with regard to the presence or absence of proper means of subsequent purification, in other words, if the State Board of Health does not insist on costly methods of protecting the original source of a supply from contamination when cheaper methods of purification will attain the same sanitary end with far greater effectiveness, we may look to a rapid development of water purification in the state of Connecticut. There are approximately 100 municipal water supplies within the state, about twenty of them publicly owned and the rest operated by private companies. Of these, so far as I am aware, there are only thirteen which are treated in regularly operated purification plants. A part of New Haven, Putnam and South Norwalk have slow sand filters; Bethel, Greenwich and New Canaan have mechanical filters; and Branford, Hartford, Meriden, a part of New Haven, Norwalk, Stamford, Torrington and Waterbury have disinfection plants. With the constantly rising standards of sanitary science it seems likely that the purification of other water supplies in the state will demand increasing attention from the engineering profession of Connecticut during the next few years.

THE POLLUTION OF NEW YORK HARBOR AND ITS REMEDY.

By Kenneth Allen, Engineer of Sewage Disposal, Board of Estimate and Apportionment of New York City.

Of the five largest cities in the world, New York alone—the greatest of these—has no system of main drainage and sewage disposal. Its 316 square miles of territory are drained, as a rule, by direct lines to the nearest points on its 580 miles of water front, where some 300 outlets discharge 550,000,000 gallons of sewage daily into the waters of the harbor, without treatment, from 2,000 miles of sewers costing $80,000,000. The strong tidal currents of the East River, the large volume of upland water brought down by the Hudson and the great extent of the bays furnish almost ideal conditions for the dilution of sewage and the final digestion of its organic contents. But as the ratio of sewage to harbor water has increased, conditions have become less favorable until now a serious nuisance from foul odors may be apprehended at almost any time in the future during hot weather at certain points.

TABLE I.

AREA OF THE METROPOLITAN DISTRICT (EXCLUSIVE OF 81 SQUARE MILES IN THE LOWER BAY AND OCEAN) IN SQUARE MILES.

Prepared by E. Kuichling.

	Dry Mainland	Principal Islands	Total Dry Land	Open Water	Marsh	Total Water and Marsh	Total Area
Manhattan	20.32	0.88	21.20	10.67	0.00	10.67	31.87
The Bronx	34.79	1.33	36.12	16.71	5.56	22.27	58.39
Brooklyn	55.68	0.00	55.68	49.34	10.73	60.07	115.75
Queens	89.63	0.00	89.63	36.58	14.27	50.85	140.48
Richmond	49.81	0.20	50.01	47.11	8.08	55.19	105.20
City of New York	250.23	2.41	252.64	160.41	38.64	199.05	451.69
Westchester County	58.37	0.09	58.46	5.32	0.09	5.41	63.87
Nassau County	5.30	0.00	5.30	2.82	0.09	2.91	8.21
Total New York	313.90	2.50	316.40	168.55	38.82	207.37	523.77
Total New Jersey	252.47	0.00	252.47	33.10	42.79	76.78	329.25
Metropolitan District	566.37	2.50	568.87	202.54	81.61	284.15	853.02

TABLE II.

MILES OF SHORE LINE—NEW YORK HARBOR.

	Commercial	Parks	U. S. Gov't	Undeveloped	Total
Manhattan	12.9	5.2	10.8	14.3	43.2
Brooklyn	30.7	3.8	3.2	163.3	201.0
The Bronx	10.0	16.0	9.1	44.7	79.8
Queens	16.6	0.9	1.3	178.0	196.8
Richmond	9.6	—	1.6	45.9	57.1
New York	79.8	25.9	26.0	446.2	577.9
New Jersey	30.9	5.4	10.3	42.5	89.1
Total	110.7	31.3	36.3	488.7	667.0

A study of the pollution of New York harbor has been carried on now almost continuously since 1903, first by the New York Bay Pollution Commission,[*] then by the Metropolitan Sewerage Commission,[†] by Col. William M. Black and Prof. E. B. Phelps for the Board of Estimate and Apportionment, and for the past year or two by the New York Sewer Plan Commission[‡] and the Bureau of Sewer Plan.[‡] Since January 1st the work has been turned over to the Board of Estimate and Apportionment, of which Nelson P. Lewis is chief and Arthur S. Tuttle, deputy chief engineer. These studies have also included the formulation of plans for main drainage and sewage disposal to secure and maintain what may be called a decent degree of cleanness in the waters of this important harbor.

The studies of the harbor up to 1910 consisted of inspections of its waters and shores, in analyses of its waters and underlying mud, in obtaining as thorough a knowledge of the currents as possible and in securing and recording data regarding population, sewage flow and the existing systems of sewerage, all of which information was required in order to judge of the seriousness of the pollution, its probable increase and the means that should be taken to restrict it.

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[*] Daniel Lewis, chairman.

[†] Geo. A. Soper, president.

[‡] N. P. Lewis, chairman.

BUREAU OF
PUBLIC
IMPROVEMENTS
BOARD OF
ESTIMATE AND
APPORTIONMENT
CITY OF
NEW YORK
FEB [illegible] 1916

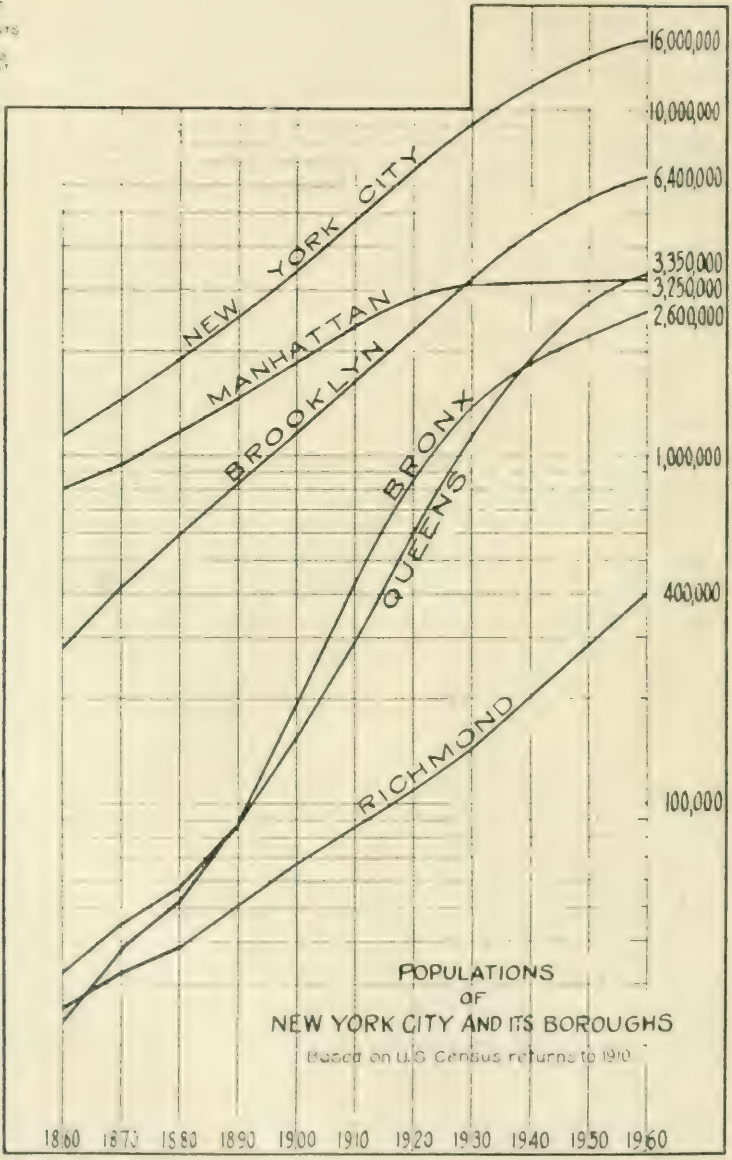

FIG. 1.

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During 1911-12, after consultation with various experts, a desirable "standard of cleanness" was formulated, and in the following years general schemes for main drainage and sewage disposal were worked out, estimates compared and those of most promise definitely recommended.

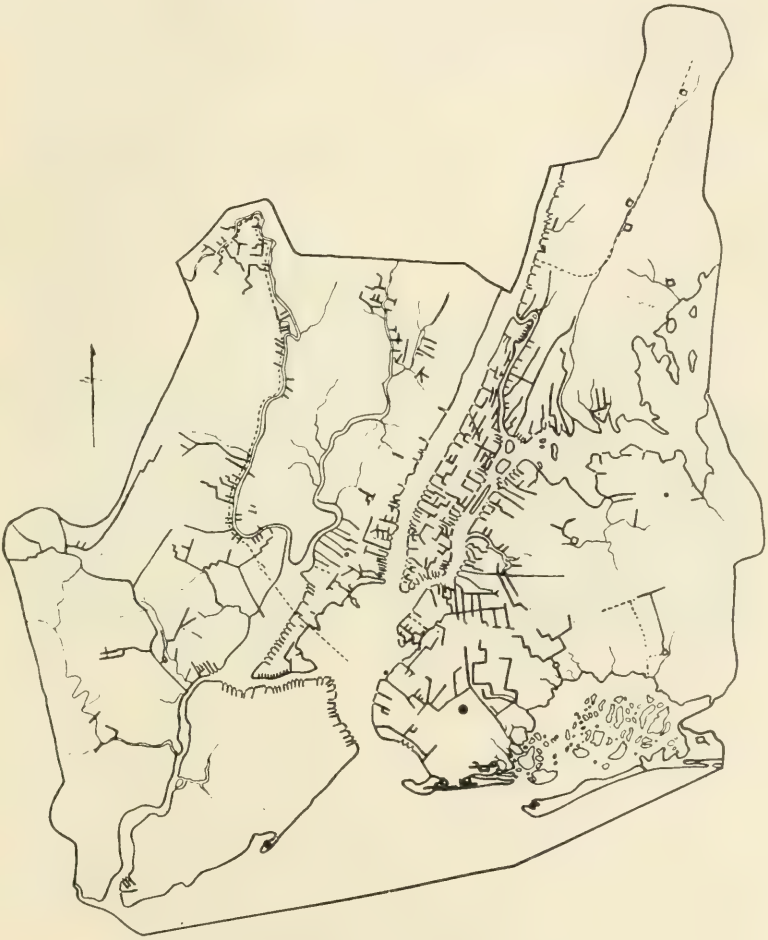

FIG. 2. SEWER OUTLETS, GREATER NEW YORK.

INSPECTIONS.

Inspections of the debris cast up by the waves on the shore, of the areas of sleek and of visible pollution from sewer outlets were frequently made, but perhaps the part of this work most directly of service to the city was in rendering the flow of sewage effluents through eight of the fifteen floating baths maintained along the water front of Manhattan and Brooklyn visible by the use of a strong dye. The dye used was "uranine," which is a sodium salt of fluorescin.* A quarter pound or so of this placed in the effluent at the nearest sewer upstream from the floating bath would color the water a vivid green. An inspector stationed in the interior of the bath house, apparently watching the swimmers, would note the discoloration as it appeared and then quietly walk out, leaving the bathers amazed at the strange sight.

FIG. 3. FLOATING BATH HOUSE IN BOROUGH OF MANHATTAN.

These polluted baths were shown in this way to be unfit for use and were subsequently abandoned or removed to cleaner waters.

ANALYTICAL WORK.

Many chemical, microscopical and bacteriological tests of the water in all parts of the harbor were made, gradually eliminating those giving the less important information until the only one

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*$(C_{20}H_{10}O_5Na_2)$.

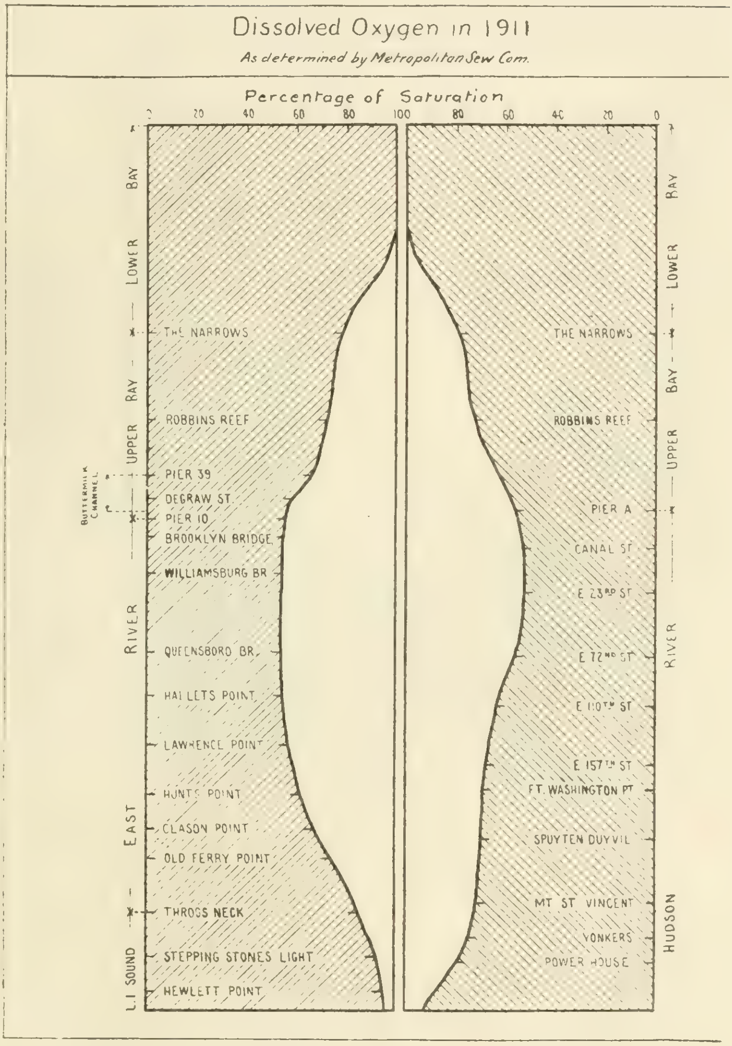

FIG. 4. DISSOLVED OXYGEN, NEW YORK HARBOR.

left was the test for dissolved oxygen.* Of all single analyses this is the most illuminating in considering questions of pollution It was found that, while the water of the open ocean is practically saturated with oxygen, the percentage decreases with the approach to the city until in the lower East River and the Harlem River it is very low, and in the foul waters of the Gowanus Canal and Newtown Creek it is frequently absent, in which case objectionable odors result.

There were, in all, some 3,710 analyses for dissolved oxygen made by the Metropolitan Sewerage Commission and a large number more recently by the Bureau of Sewers, Manhattan, under C. E. Gregory, chief engineer. Their importance is shown by the discovery of a marked decrease in the per cent saturation in the lower East and Harlem Rivers, indicating an approach to a condition when a nuisance will develop unless checked by remedial measures. These tests have shown the following average percentages:

AVERAGE PERCENTAGES OF DISSOLVED OXYGEN.

	1909	1911	1913
Lower East River	65	54	43
Harlem River	55	42	29

MINIMUM PERCENTAGES OF DISSOLVED OXYGEN.

	1909	1911	1913	1915
Lower East River	56	51	11	19
Harlem River	21	19	11	0

TABLE III.

LOW SUMMER PERCENTAGES OF DISSOLVED OXYGEN.

	1909	1911	1912	1913	1914	1915
Harlem River:						
106th Street	21	19	—	13	16	25
Willis Avenue Bridge	32	29	21	19	0	0
Morris Heights	46	40	33	11	7	8
Spuyten Duyvil	56	52	34	14	23	—
Lower East River:						
23d Street	56	—	—	13	28	19
42d Street	58	51	29	—	26	27
Pier 10	56	51	25	11	19	21
Hudson River: Pier A	56	51	42	20	32	40
The Narrows	67	65	61	52	45	54

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* The analytical work was largely done by Dr. P. B. Parsons, W. R. Copeland and D. D. Jackson.

It is the minimum degree of saturation, which occurs in the hot weather of August and early September, that is most significant, as it is this that indicates the approach of what may suddenly develop into a serious nuisance, such as has been experienced in the past in the Thames at London, the Seine at Paris, the Passaic at Newark, the Chicago River and Bubbly Creek at Chicago, and the Inner Harbor at Baltimore. Residents of these places can testify to the detriment such conditions entail and the effect on real estate values.

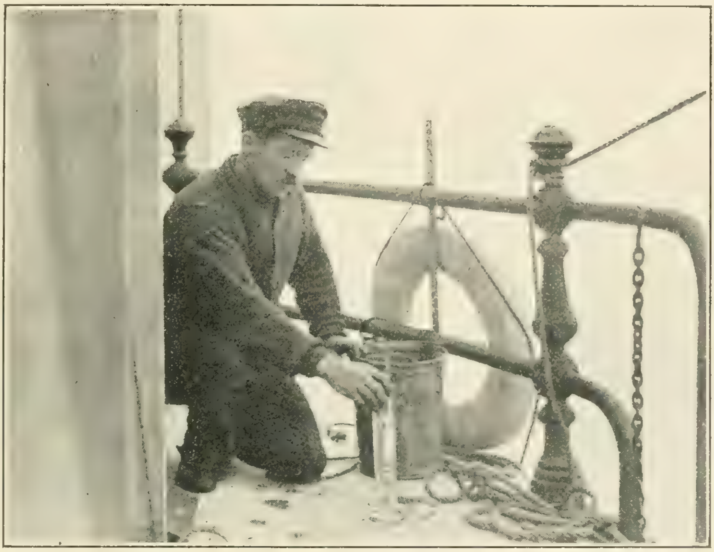


FIG. 5. DETERMINING THE PROPORTION OF SEA WATER BY MEANS OF A SALMOMETER.

TIDAL CURRENTS.

The currents of the waters of New York harbor, upon which their capacity for diluting sewage depends, are so varied, complex and dependent upon so many conditions of wind, rainfall, phase of moon and topography of the bottom, that it is very difficult to determine such matters as average velocities, volumes of upland and tidal flow, etc. Most valuable information, hitherto in part unpublished, was furnished by the United States Coast and Geodetic Survey, but this was supplemented by

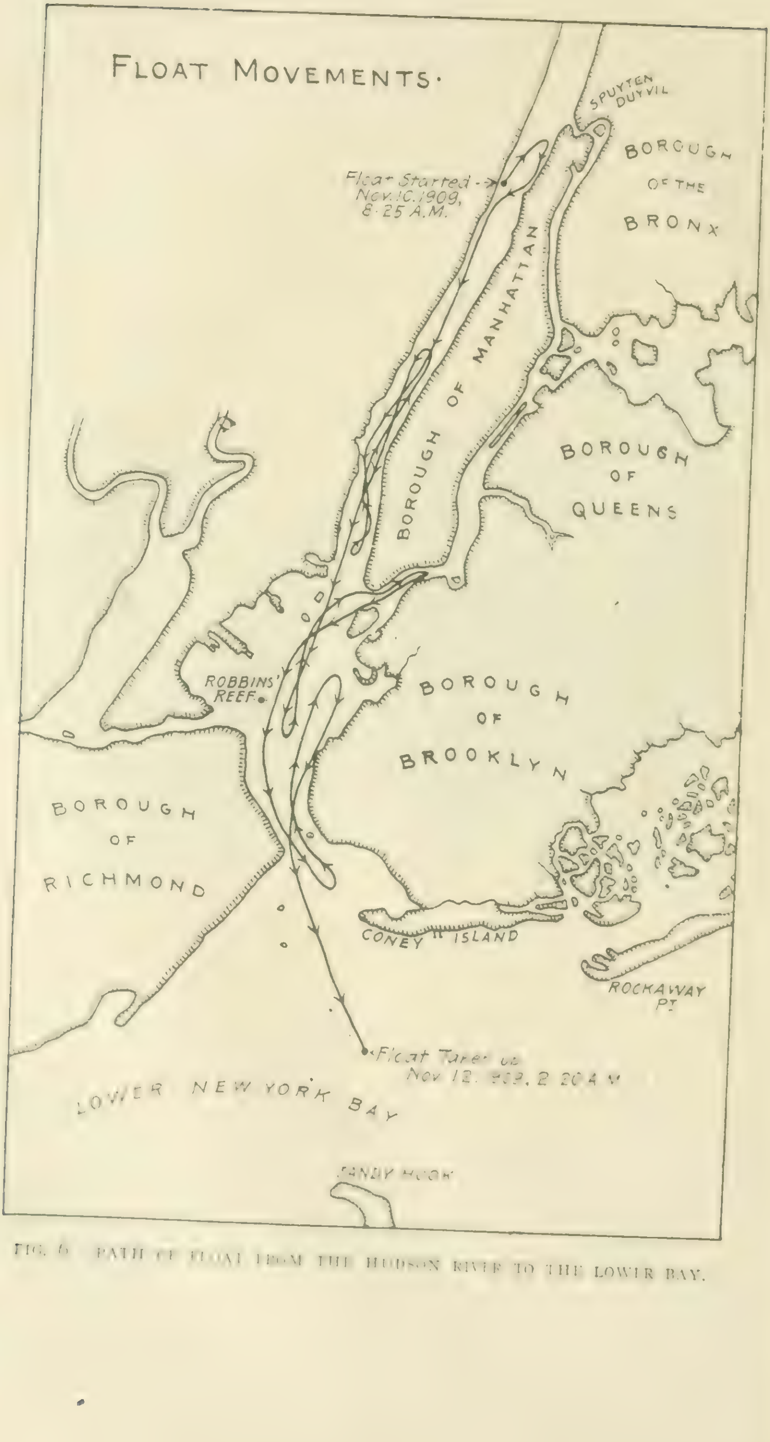


FIG. 6. PATH OF FLOAT FROM THE HUDSON RIVER TO THE LOWER BAY.

numerous float experiments made by the Metropolitan Commission and by a series of salinity determinations which gave an excellent measure of the mixing effect of the sea water entering at the Narrows at the South and from Long Island Sound at the East with the fresh water brought down by the Hudson and Passaic Rivers.

These observations were carried out at eleven lighthouse stations three times a day for a year and various others were made at other points. Of particular interest and value was a series made April 13-15, 1909, from the eastern end of Long Island Sound to the south end of the lower East River, as follows:

TABLE IV.

PERCENTAGE OF SEA WATER IN LONG ISLAND SOUND AND THE EAST RIVER

Greenport Harbor and Rocky Point	90
Hortons Point and Jacobs Landing	88
Roanoke Landing and Herods Point	86
Woodville Landing	84
Mt. Misery Point	82
Smithtown Bay and Eatons Point	80
Lloyds Point	78
Matinicock Point	76
Prospect Point	74
Throgs Neck	70
Classon Point	64
Williamsburgh Bridge	60
The average noted April 15 at Governors Island in New York Upper Bay was	34.8%

This uniform decrease from the East to the West was the most conclusive proof that there existed a resultant tidal flow from the Sound toward the Narrows, as otherwise the waters of the west end of the Sound would have more closely resembled those of New York Upper Bay. The several gagings of the East River made by the Coast Survey and the War Department were discordant, probably on account of the temporary conditions when made.

Passing out to sea through the Narrows the percentage of sea water increases again from 63 per cent at the Narrows to 92 per cent in the Lower Bay and 100 per cent in the Ocean off Long Branch.

The flow of water toward the ocean from the harbor through the Narrows is an important element in the capacity of the harbor to care for sewage. It averages 1,282,000,000 cubic feet per tidal period of twelve lunar hours, most of which is due to the discharge of the Hudson River.

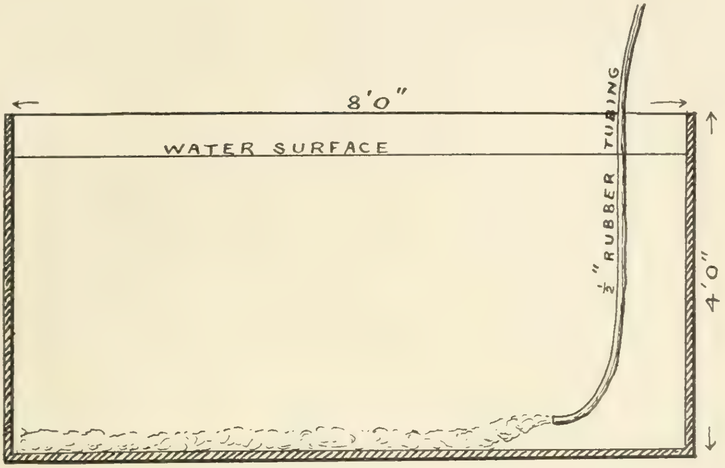
DIFFUSION.

Interesting experiments were made to observe the diffusion of sewage in harbor water, first with thirty-one experiments on a small scale in the laboratory, then with twelve in a tank about eight feet long and four feet deep in the New York Aquarium, and finally with thirty in the harbor itself.

Either tap water or sewage colored with uranine or some other dye was injected at different depths and in different volumes into water of different degrees of salinity. As observed in the laboratory by dropping from a pipette or a fine drawn glass nozzle, some of the forms assumed were very beautiful. The form was usually an inverted cone, but circles resembling smoke rings, vertical columns of cumulus appearance, similar to the dense smoke rising from a burning oil tank on a still day, were noted. The form depended, of course, on the velocity of the jet and the relative density of the two liquids.

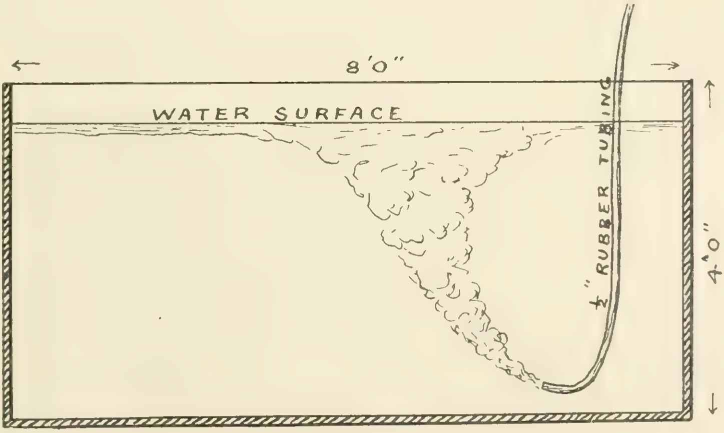
To show the relative rapidity of diffusion in waters of different degrees of salinity 30 cc. of sewage colored with $\frac{1}{10000}$ part of uranine was discharged gently from a pipette on the surface of 3,000 cc. of the water in a Mason jar. When the jar held tap water only, diffusion began in a few minutes and was complete in an hour; when it contained 25 per cent of sea water, diffusion was not complete until forty-eight hours; with 50 per cent sea water not until fifty-six hours; and with 75 per cent sea water and 25 per cent tap water diffusion remained incomplete at the end of a week. The experiment brought out the great advantage, so far as diffusion is concerned, in a discharge of sewage into fresh water.

One of the most interesting of the Aquarium experiments consisted in the discharge of colored sewage into tap water from a $\frac{1}{2}''$ jet under a head of 0.15 feet in a horizontal direction at a depth of 3.4 feet—that is, at the bottom of the tank. The sewage first spread out in the form of a blanket about two inches thick over the bottom of the tank and then, after about three minutes,



JET OF SEWAGE IN UPLAND WATER

FIG. 7.



JET OF SEWAGE IN BRACKISH WATER

FIG. 8.

began gradually to diffuse. Within about a half hour diffusion was complete throughout the tank. When, however, the discharge was into salt or brackish water the sewage rose in a cone to the surface, where it spread out in a thin layer and then diffused. This illustrated clearly the tendency of sewage to remain near the bottom if discharged horizontally into fresh water until diffusion takes place.

In the thirty outdoor experiments the colored liquid was pumped to different depths at different points in the harbor and the appearance of the dye on the surface noted.

When three and one-third pounds of uranine was dissolved and dumped in the harbor water it could usually be readily detected after flowing one and one-quarter miles in a current of two and one-half miles per hour. Two and one-half pounds could likewise be detected at this distance if the current were 1.6 miles per hour. If conditions of light were good and unless greatly diffused the field of color was readily visible from the deck of a launch at a distance of 2,000 feet.

Most of these experiments were made by pumping a dilution of one part uranine in about 2,000 of tap water or sewage from large casks, holding in all about 1,000 gallons, through a 1¼" hose to different depths with a velocity of six and one-half feet per second and noting the result at the surface.

At the proposed location of the Passaic Valley Sewer outlet near Robbins Reef when the specific gravity of the harbor water was 1.020, a 1:500 solution of uranine pumped to a depth of forty feet was discovered at the surface.

On another occasion 16,500 gallons, having a dilution of 1:2750, was pumped through a 2½" hose to a depth of forty feet with a velocity of fourteen feet per second. The specific gravity of the harbor water at this time was 1.0125. No sign of the dye was, however, noted at the surface.

In a yet larger test 56,000 gallons of tap water containing 290 pounds of uranine were pumped from a pontoon through an eight inch pipe to a depth of forty feet at a rate of 2,320 gallons per minute. The velocity of the current at a depth of three feet was 0.45 feet per second; at a depth of 20 feet 1.03 feet per second and at a depth of fifty feet, 2.85 feet per second. At the point of discharge, forty feet below the surface, it was estimated at 2.2 feet per second. The specific gravity of the harbor water ranged from 1.015 at the surface to 1.018 at a depth of fifty feet and the temperature was 72° F. In spite of the large volume discharged this was not detected on the surface.

Several important conclusions are drawn from these seventy-nine experiments relative to the discharge of sewage into bodies of water.

In the first place the effluent will rise in still water toward the surface or fall, depending solely on the relative specific gravity of the two liquids. In sea or harbor water it will rise, while in upland water of considerable purity it will remain at the level of discharge or fall toward the bottom.

Immediately after its discharge sewage begins to diffuse and commingle with the surrounding water. This diffusion will take place more rapidly the less the salinity, and probably bears some relation to the volume, or exposed surface, of the effluent; but at this stage diffusion is of less importance than the mixing action or dispersion. The latter depends largely on the relative velocity of the sewage effluent and the stream into which it is discharged. If the current is rapid or with turbulent eddies the mixing will be rapid and may obliterate any buoyant effect due to the original specific gravity of the sewage. In equal mixtures of sea and upland water, however, sewage will rise and may be expected to reach the surface so as to be detected from depths up to thirty feet. From depths of from thirty to forty feet it is uncertain whether it will make its appearance. Much depends upon sub-surface currents. But at depths greater than forty feet it is not likely to be seen at the surface unless discharged in very large volumes.

In still water of from .004 to .016 greater specific gravity sewage will rise at the rate of from 0.10 to 0.17 ft. per second.

VISIBLE EVIDENCES OF POLLUTION.

Inspections of the water front and of the channels were considered of much importance as furnishing the most direct evidences of pollution and those which would soonest result in popular criticism and complaint. The small but important waterways in Brooklyn known as the Gowanus Canal and Newtown Creek were found to be most foul and objectionable, bubbling with sulphureted hydrogen from the sludge deposits beneath and putrescing actively in warm weather*; various slips near sewer outlets were in nearly or quite as bad a condition owing to sludge deposits; feces and other objectionable evidences of sewage were generally found near outlets and in the lower East River, at times, from shore to shore; sleek from sewage and oil scum from trade wastes were common and at times objectionable; the current near sewer outlets was visibly clouded for long distances and sewage solids with debris of all kinds found their way to a lodgment on the shores.

When one considers that New York is one of the great ports of the world, that there arrive here most of the immigrants and tourists from abroad besides a vast daily population by steamship lines and ferries from domestic points—in round numbers 4,500 foreign and 5,000 domestic vessels besides the local passenger traffic†—and then thinks of the comparative cleanliness of the harbors of London, Glasgow, Hamburg and Rotterdam, the importance of improving these conditions in New York harbor is realized.

STANDARD OF CLEANNESS.

It was believed desirable that a standard of cleanness for the waters of New York Harbor should be established and eight eminent authorities were consulted on this point, viz.: Dr. W. E. Adeney of Dublin, Dr. Charles V. Chapin of Providence, Harrison P. Eddy, Prof. W. T. Sedgwick and Desmond FitzGerald of Boston, Prof. W. P. Mason of Troy, Prof. C.-E. A. Winslow of New York and F. Herbert Snow of Harrisburg, Pa.

After collating and weighing the suggestions made, the Metropolitan Commission formulated the following five provisions which, in their opinion, it were desirable to adopt:

STANDARD OF CLEANNESS PROPOSED BY THE METROPOLITAN SEWERAGE COMMISSION.

1. Garbage, offal or solid matter recognizable as of sewage origin shall not be visible in any of the harbor waters.

2. Marked discoloration or turbidity, due to sewage or trade wastes, effervescence, oily sleek, odor or deposits shall not occur

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* The situation in the Gowanus Canal has since been relieved by flushing from the upper end through a 12′ tunnel to the bay.

† Probably over 200 million ferry passengers per annum.

except perhaps in the immediate vicinity of sewer outfalls, and then only to such an extent and in such places as may be permitted by the authority having jurisdiction over the sanitary condition of the harbor.

3. The discharge of sewage shall not materially contribute to the formation of deposits injurious to navigation.

4. Except in the immediate vicinity of docks and piers and sewer outfalls, the dissolved oxygen in the water shall not fall below 3.0 cc. per litre of water.* Near docks and piers there should always be sufficient oxygen in the water to prevent nuisance from odors.

5. The quality of the water at points suitable for bathing and oyster culture should conform substantially, as to bacterial purity, to a drinking water standard. It is not practicable to maintain so high a standard in any part of the harbor north of the Narrows, or in the Arthur Kill. In the lower bay and elsewhere bathing and the taking of shellfish cannot be considered free from danger of disease within a mile of a sewer outfall.

STANDARD OF CLEANNESS PROPOSED BY MESSRS. BLACK AND PHELPS.

In a report on the disposal of New York's sewage made by Col. William M. Black and Prof. Earle D. Phelps to the Board of Estimate and Apportionment February 16, 1911, these gentlemen say: "After a careful consideration of the whole question, the writers recommend that for New York 70 per cent of the saturation value be adopted as a standard below which the dissolved oxygen in its harbor waters be not permitted to fall—a standard of which the maintenance can be made evident by the existence of the major fish life formerly so abundant here."

STANDARD OF CLEANNESS PROPOSED BY THE NEW YORK SEWER PLAN COMMISSION.

The New York Sewer Plan Commission suggested provisional standards of cleanness in a report dated May 15, 1914, for each of thirteen subdivisions of the harbor, dependent on their character and present condition. In general, these provide that:

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* With 60 per cent of sea water and 40 per cent of land water and at the extreme summer temperature of 80° F., 3.0 cc. of oxygen per litre corresponds to 58 per cent saturation.

1. Bathing and shellfish culture shall be prohibited from the inner harbor.

2. Treatment "be established sufficient to the extent necessary to keep all parts of the Harbor at all times free from visible solid matter of sewage origin, noticeable discoloration, fields of oily sleek, odors due to sewage or trade wastes, material deposits of sewage sludge and to maintain in each harbor unit at all times, under the most unfavorable conditions of tide, depth, location, season and temperature, not less than certain specific quantities of dissolved oxygen.

"It is believed that the dissolved oxygen in some of the units of the inner harbor may safely be allowed at times to fall somewhat below 20 per cent of saturation. . . .

"The works required for a long time to come will probably include only fine screening or sedimentation combined with proper distribution and diffusion into the main channels, except . . . . where further refinements in the treatment of sewage, even in some cases to the extreme of sterilization, may be required for the purpose of temporarily preserving bathing beaches and suitable conditions for the shellfish industry."

There is thus seen to be a very general agreement as to the standards to be maintained with the exception of that for dissolved oxygen, on which various authorities suggested from 70 per cent saturation down to 20 per cent or less. The Metropolitan Commission finally eliminated this provision entirely on the contention that if the other standards were observed the oxygen would be maintained sufficiently high. On the other hand, the dissolved oxygen is generally admitted to be the best general index as to the extent of pollution and so others have believed that it should be given particular prominence. As a general proposition it may be said that, with the exception of the Harlem River, if the visible impurities are removed from the harbor waters and the oxygen content maintained at the figures which obtain at the present time in the main channels no serious objection can be found; but to maintain this condition the general treatment of effluents will have to be introduced and the sludge deposits which are to be found along the water front removed by dredging.

AVAILABLE METHODS OF TREATMENT.

Only well-known standard methods of treatment have been considered in connection with plans for the future. Although it has been estimated that the solids which find their way to the harbor would make over 14,000,000 cubic yards of sludge each year, it is probable that the larger part of this is digested and removed by natural processes in the harbor itself and that a part passes out to the lower bay, leaving a comparatively small proportion which settles as sludge on the harbor bottom. The harbor waters are therefore an important agency in disposing of the sewage which enters them and if diffusion were perfect there could be little reason to apprehend trouble through putrefaction.

Such treatment as by sprinkling filters or other oxidizing processes will therefore not be required except to a very limited extent—perhaps near the head of Jamaica Bay.

The general mode of treatment will probably be by sedimentation and by fine screening, in order to remove those ingredients that offend the eye and cause sludge deposits. The exact relative efficiency and cost of these two processes yet remains in doubt although it may be said in general that tank treatment will usually remove a larger percentage of solids. It is hoped that more definite information regarding fine screening will be available within the next two years so that a selection between the two may be made with more confidence than at present. Meanwhile the policy is to plan for screening where the elimination of the larger visible solids is sufficient, while sedimentation plants will be assigned to those locations where the oxygen is in danger of falling below a reasonable limit.

PLANS FOR MAIN DRAINAGE.

Although the public is hardly yet aware of the urgency for carrying out systematic improvements to ameliorate the general conditions in New York harbor, the City authorities and those experts who have had occasion to look into the matter are in complete agreement that at least:

1. Visible evidences of sewage pollution should be prevented.
2. Sludge deposits should be, so far as practicable, removed and prevented.

3. A comprehensive plan to protect the harbor from any increased pollution should be prepared at this time, subject to modification, to which all plans for main drainage and sewage disposal shall conform.

The Metropolitan Sewerage Commission drew up such a general scheme covering the entire city. In brief this comprised

1. Treatment of the sewage entering the Hudson and in part that entering the lower East and upper East River and the upper bay and that from the Borough of Richmond by a number of isolated fine screening and sedimentation plants.

2. Treatment of the sewage entering the Harlem River by sedimentation on Wards Island.

3. Treatment of 200,000,000 gallons per day of the sewage tributary to the lower East River by sedimentation on an artificial island to be constructed 3 miles off shore from Coney Island.

4. Treatment of the sewage entering the upper part of Jamaica Bay by sprinkling filters on an island of the bay and of the sewage entering the lower part of the bay (chiefly from Brooklyn) on Barren Island at Rockaway Inlet or else diverting this into the tunnel delivering the East River sewage to be treated on the artificial island off Coney Island in the lower bay.

The rejection of the artificial island scheme by the City authorities has led to various modifications in these plans. Under the Bureau of Sewer Plan coöperating with the sewer bureaus of the several Boroughs certain definite projects have been worked out in conformity with a general plan and tentatively adopted which, if carried out, will relieve the Harlem River of its present dangerous load of pollution and abate a number of local nuisances in the East and Hudson Rivers.

In brief, it is proposed to carry the sewage of Kingsbridge to the Hudson at Spuyten Duyvil where it will in the future be screened and discharged. The rest of the sewage tributary to the Harlem River from the Bronx and Manhattan it is proposed to concentrate at 156th street and Eighth avenue, Manhattan, and carry thence by a tunnel under 155th street to the Hudson River where, with the Manhattan sewage tributary to the same point, it will eventually be fine-screened and discharged at a considerable distance from the shore.

The sewage of the Bronx entering Bronx Kills and the upper East River west of the Bronx River will probably be treated by sedimentation on Rikers, and perhaps in part on Wards Island and discharged into that river.

Along the balance of the Hudson and East River the sewage will probably be intercepted to a reasonable number of points for disposal where it will receive either fine screening or settling in tanks before discharge. The sewage tributary to the lower East River will require, if anything, the more thorough treatment and a certain volume may be intercepted and carried toward the Narrows for final disposal.

These plants, while doing away with various existing nuisances will, if authorized, provide a final method of disposal for the sewage entering these streams, two of which, the Harlem and East Rivers, require immediate relief.

There remain large areas in Brooklyn and Queens where the topographical conditions render main drainage a difficult problem, but for which plans must be prepared in the near future to protect the waters of Jamaica Bay, and as local nuisances due to improper sewerage conditions crop up from time to time it will be the province of the Board of Estimate to exercise sufficient control over the adoption of plans to see that they are in accord with lines of development that should be ultimately carried out.

CONCLUSION.

Probably no more thorough investigation of harbor pollution has ever been made than in the case of New York. It has been approached from every possible view-point and passed upon by not only the many experts called in by the Metropolitan Sewage Commission and the City and State of New York for this purpose, but by many more who presented testimony for or against the project for discharging the sewage from the cities of the Passaic Valley into New York Upper Bay. This testimony has not yet been published on account of its enormous volume. The subject has also received serious consideration and study from the Board of Estimate and the engineers of the several Boroughs.

Within a generation a population of 12,000,000 or 14,000,000 persons will be tributary to the harbor—more than twice the present number. The importance of forestalling the unsavory situation that would certainly arise if a *laissez faire* policy were permitted in the meantime was well expressed by Prof. W. T.

Sedgwick in his report on a Standard of Cleanness. He says: "I wish it might be possible for your Honorable Board to convince the people of Metropolitan New York, as I am convinced, that no investment, however great, would be too large to secure the complete and perpetual conservation of these waters for purposes of health, of pleasure and of agreeable and attractive commerce. Nor is this condition merely an iridescent dream. A sum such as is already set apart for clean, pure, drinking water for the metropolis would go far toward making this a reality. . . ."

I might add that the estimates of the Metropolitan Sewerage Commission were about one-third the amount required for the new Catskill water supply, or $54,000,000, to be used within the next twenty years.

Unfortunately New York is already burdened with a large floating debt so that it has heretofore been the policy to meet the costs of such improvements as are comprised in the terms "main drainage" and "sewage treatment" by local assessment. This policy, if continued, would undoubtedly tend to restrict the adoption of such improvements, for it will be at once recognized that the benefits to be derived are of a particularly general character, affecting the City as a whole and its good name rather than any one locality. But a beginning has already been made by authorizing several projects involving the disposal of sewage and signs are not wanting that others will soon follow. If these are so coordinated as to produce a harmonious and efficient system in the end as well as to meet present exigencies, the preliminary investigations which have been made at so great an expense will not have been made in vain.

FEDERAL VALUATION OF RAILROADS.

By H. L. Ripley, Valuation Engineer, N. Y., N. H. & H. R. R.

Your president little realized the burden of reproach he was assuming when he asked me to speak to you this morning about the work that has been occupying my attention for the past two years.

At the outset I planned to confine my remarks to the method of procedure on the New Haven Road and wrote several pages of descriptive matter outlining the detail of the work. Then I read it over and decided such a paper would be about as interesting to you gentlemen as would a discourse on Babylonian art. Then I tore it up.

If I had the wit of a Mark Twain I would do as he so frequently did, use the subject simply as a peg on which to hang the first story. But I can't tell a story, much less originate one, so I shall be compelled to stick to the text assigned me, "The Federal Valuation of Railroads."

The work is being done under a Federal law enacted March 1, 1913 (62d Congress H. R. 22593), amending an act to regulate commerce, approved February 4, 1887, and familiarly known as the Interstate Commerce Law.

The fundamental requirement of the law is contained in the first sentence of the first paragraph, namely: "The Commission shall, as hereinafter provided, investigate, ascertain, and report *the value* of *all* the property *owned* or *used* by every common carrier subject to the provisions of this Act."

The remainder of the act is subordinate to and in amplification of the requirements of this first sentence, or gives specific instructions as to the method to be followed and machinery to be used in carrying out the requirements of this first and fundamental order.

The act authorizes the commission to employ such experts and assistants as may be required and directs them to list the property in detail and classify the physical property, as nearly as practicable, in conformity with the uniform system of accounts prescribed for the classification of investment in road and equipment.

First—The Government is required to ascertain and report in detail as to each piece of property owned or used; the original cost to date; the cost of reproduction new; the cost of reproduction, less depreciation, together with an analysis of methods used and differences found, if any. This covers the cost and present value of the physical units of property. They are also directed to ascertain and report, separately therefrom, other values and elements of value, analyzed to show any differences between such value and the three cost values.

Second—They are instructed to report in detail, separately from improvements, the original cost and present value of land and, separately, the original and present cost of condemnation and damages or of purchase, in excess of such original cost or present value.

Third—To show separately the property held for purposes other than those of a common carrier.

Fourth—To report the history, corporate and financial, of the present carrier, its predecessors and its underlying and dependent companies.

Fifth—To report the amount of all aids, gifts, grants or donations, to and from the carrier, whether made on the part of public bodies, corporations or individuals.

General Clauses—Provide among other things that the commission shall have full power to determine methods of procedure and form of report, subject only to the specific requirements of the act, and shall show "the value" as a whole and by states.

Coöperation—The act provides that the carrier shall allow the agents of the commission free access to all its property and its records; render such assistance as may be required; provide copies of such records, documents and maps as will aid in the work and coöperate in every helpful way to such extent as the commission may require.

Additions and Betterment—The law provides for a systematic recording of additions, deletions and changes, and for a systematic review of the work in order to keep it up to date.

Tentative Valuation—It requires the commission to make, first, a tentative valuation subject to exceptions to be taken within thirty days, by any party at interest, failing which the valuation so reported shall become final.

In case of protest a method of procedure is outlined for review, correction and for final finding as to the value of the property, which value shall become *prima facie* evidence in all judicial proceedings under the act.

Penalties are provided for failure on the part of the carrier to coöperate in carrying out the provisions of the act.

Reason and Scope—The reason for the act, and the necessity for, and scope of the work, was pretty clearly outlined in the report of the Committee of the Senate (Calendar No. 1142, Report No. 1290, 62d Congress, 3d Session) and in previous reports of the I. C. C. Some of them follow: For use in general rate cases; for comparison between capitalization, original cost and present value; for taxation purposes; to set up a correct balance sheet; to provide an equitable basis for reimbursement under condemnation proceedings, looking to government ownership.

Orders—Pursuant to the requirements of the act, which calls for the coöperation and assistance of the carrier, the commission has served twenty (20) formal orders upon the railroads.

Orders Nos. 1 and 5 (map orders) call for complete maps and profiles of the property, showing the boundaries of each individual parcel of land purchased, with a citation of the evidence of title, parcel number, grantor, grantee, kind of instrument, date, reference to public record, reference to custodian's file and explanatory remarks.

On the same map (or on another covering the same territory in congested districts) must be shown all tracks and principal structures, and minor structures so far as practicable.

Maps must be made in accordance with minute, detail specifications, on tracing cloth 24″ x 56″, in black india ink, using standard A. R. E. A. symbols to designate the structures; signed by an accredited officer of the company and certified before a notary.

On the New Haven and the Central New England Railways this meant 1,100 miles of complete new survey, first reëstablishing the original center line; a review of 450 miles of line where the survey was made and the center line reëstablished and monumented in the eighties; and 750 miles where survey had been made and center line monumented for real estate purposes in recent years. It meant the preparation of 2,300 miles of new maps in accordance with the specifications, including the placing, plotting and listing thereon of some 30,000 evidences of title.

Nos. 2 and 10 (abandoned property) call for a complete and detailed schedule of abandoned property, with a statement of the carriers' claims in relations thereto.

As no one has yet evolved a satisfactory definition of what constitutes abandoned property or the principles which should govern its inclusion in, or omission from, the inventory, the matter is in abeyance, and, being too deep for the solons to decide, the junior field engineer is pretty generally settling it for himself as he goes over the line. Our pilots are reporting his decision to the office, from which reports a schedule can be prepared. Eventually a decision will have to be reached in this matter, and the carriers will then have to file claims covering so much of this class of property as it is decided should be included in the inventory.

For instance, in the "cost of reproduction new," there would seem to be no question of the carrier's right to have included so much of this property as would be used and useful under a rational engineering programme in building the roadway and structures now in service. There might be doubt of its right to include an old roadbed permanently, and voluntarily, abandoned.

No. 3 (extensions, improvements and changes) calls for a detailed report of all extensions, improvements or other changes in physical property, made subsequent to the valuation date. This includes deletions as well as additions or betterments, and provides the machinery for keeping the valuation up to date. It requires not only the reporting of changes in physical units but also a detail and analysis of cost which will enable the government to keep track of prices and price tendencies, and so revise the valuation from time to time to meet conditions as they may then exist.

No. 4 (movable property) calls for an inventory of material and supplies. It was the intent of this order to require only a report of such unapplied material as the storekeeper carried in his stock, but the carriers generally have felt that it was incumbent upon them to schedule applied material, supplies, and tools as well. Otherwise a large percentage of this loose property is bound to be overlooked in the hurry of the government inventory, and it amounts to many thousands of dollars on the New Haven road. Some items which might easily escape notice are:

Hand tools.
Stationery.
Tickets.
Baggage checks.
Material in transit, including coal.
Dining car equipment and supplies.
Freight car seals and seal presses, etc.

Passenger time table folders cost	$45,000 per year
Employees time table folders cost	6,000 per year
Printing Operating Dept. Book of Rules	8,640
Compiling Operating Dept. Book of Rules	8,000 (more or less)
The last edition of wall maps cost	7,500
Employees' working agreements cost	980
Book of general instructions to agents and others cost	2,450 (one issue)
Passenger conductors' outfits cost	9,300

These are only a few of the many items of a similar nature.

No. 7 (land) calls upon the carrier to furnish a complete schedule, typewritten, in duplicate, showing as to each instrument conveying right, title or interest in or to land, the character of the instrument and date, reference to file of both railroad and public record, the grantor and grantee and the consideration recited in the instrument; together with the sheet and parcel number on the map, the area, the cost in detail, showing the amount and character of each expenditure which entered into such cost, separated as between the original parcel and the remaining portion, if any of it has been sold, together with the date of sale and the money or other consideration received therefor.

The foregoing information is required to be stated separately for land now held for common carrier purposes and land held for other than common carrier purposes.

We estimate there are about thirty thousand (30,000) separate instruments to be reported under this order.

No. 8 (equipment) calls for a register of equipment owned or used by the carrier covering:

Account 37 Roadway machines.
44 Shop machines and tools.
45 Power plant machinery.
46 Power sub-station apparatus.
51 Steam locomotives.
52 Locomotives other than steam.
53 Freight train cars.
54 Passenger train cars.
55 Motor equipment of cars.
56 Floating equipment.
57 Work equipment.
58 Miscellaneous equipment.

This order has been extended to cover in addition:

Coaling stations.
Pumping stations.

The data wanted vary somewhat but perhaps roadway machines and steam locomotives are typical. The first asks for:

No. of units.
Trade name.
Builder and No.
Carriers' No.
Size or capacity.
Kind of drive.
Date purchased.
New or second hand.
Remarks.

This information must be compiled for each machine, or group of like machines or tools, purchased.

On steam locomotives they require:

Locomotive No.
Initials of owner.
Date built.
Builder and builders' No.
Type (Whyte symbols).
Cylinders (diameter and stroke).
Service (freight, passenger, etc.).
Diameter of drivers over new tires.
Working steam pressure.
Weight on drivers.
Tractive effort by I. C. C. formula.
Diameter of boiler outside of first ring.
Tender capacity (water, fuel).
Weight light (engine, engine and tender).
Mileage since last general repairs.
Remarks.

After the register has been completed a secondary report must be made showing the original cost to date, giving for locomotives the

Locomotive No.
Builder.
Date built.

Weight light (engine, engine and tender).
Freight data (F. O. B. point, receiving point).
Original cost to date (in dollars, separated between): (*a*) Designs, inspection, messenger service, setting up, breaking in, fixtures, tools and miscellaneous. (*b*) Freight paid. (*c*) Total. (*d*) Net cost of additions and betterments. (*e*) Grand total. (*f*) Remarks.

No. 9 (transportation) covers transportation of government employees over the lines of carrier under valuation.

No. 11 (records) calls for an inventory or index of all the records of the company, or its predecessor's company or companies, having to do with its history or its accounts.

No. 12 (industrial sidings) calls for a complete statement in prescribed form covering all industrial tracks or commercial sidings served by the carrier; that is, each track which the carrier has not an unrestricted right to use in serving the public, but which it has obligated itself to use instead exclusively or preferentially in serving a particular industry. It must show the index reference to the map; the parties to and date and form of agreement, and the amount of and division of ownership as between the carrier and the industry.

No. 13 (complete schedule furnished) empowers the director of valuation to call upon the carrier for a complete inventory of any or all classes of property and is intended to be used if, in his judgment, the carrier is not showing due diligence in preparing the necessary pre-inventory information, and proper coöperation in carrying on the work. So far it has not been invoked against any carrier so far as I am informed.

No. 14 (cost data) calls for a statement of prices paid for labor and material, covering most of the items entering into the construction of a complex railroad property.

This statement was compiled on eighty-seven prescribed forms, 11" x 17", containing from one to forty pages each, a total of 357 pages, and necessitated a complete search of the purchases made by the company over a period of five or ten years as was stipulated on each form.

No. 15 (leases and privileges) calls for a statement of leases and privileges showing in detail the index data, name, purpose, location, character, stipulation and reservation, etc. Certain exceptions are made as to particular classes of leases which do not have to be reported.

No. 16 (aids, gifts, grants, donations) calls for a statement in detail showing aids, gifts, grants and donations, from and to a carrier, covering both property and money contributed or service rendered.

Nos. 17 and 18 (telephone and telegraph company cost data) call upon telephone and telegraph companies for certain cost data and do not apply to railroads.

No. 19 (cost data) calls for the same class and character of information, regarding the cost of telephone and telegraph property of the carrier as is called for in Order 14, covering the cost of other railroad material and labor.

No 20 (history) calls for a complete outline of the corporate history of the carrier and each predecessor company, showing organization and dissolution, corporate name; name changes, authority for, and date and sequence of construction; period of time and territorial limit of operation; chain of title from parent to present company and a schedule of all general deeds, leases, reorganization proceedings and other instruments bearing upon the corporate history.

In addition to above narrative it calls for the preparation of a chart showing the chain of title in diagrammatic form.

Other orders, we understand, are pending covering such matters as trackage rights, joint facilities, etc.

Organization of Government Forces—At the head of the government organization is the director of valuation, Judge C. A. Prouty of Vermont, who retired from the commission to take up the work.

An advisory board of three members, later to be increased, we understand, to five, assists the director. At present the board consists of Messrs. Staples, Bemis and Maltbie, with Mr. Farrel as counsel for the department and Joseph W. Folke, chief counsel for the commission.

Reporting to the director are three departmental boards, covering the three principal fields of effort, engineering, land, accounting. Each board consists of five members and a chairman, with the exception of the engineering board, which has no permanent chairman. The country is divided into five geographical districts and a board member is assigned to and supervises the work of his department in each district.

The carriers are organized to meet the requirements of the law and render the coöperation called for in the act.

The president's conference committee, with Mr. Samuel Ray, president of the P. R. R., chairman, handles matters of general policy and reviews the work of the subordinate committees on engineering, land and accounts.

Each of the committees consist of about fifteen members and are subdivided into three groups representing the East, the West and the South, each with group headquarters and a working organization.

Mr. Thomas W. Hulme, secretary of the president's conference committee, is chairman of the sub-committees. Each road is represented by a valuation committee which for the New Haven and the Central New England consists of Mr. A. P. Russell, valuation counsel, chairman; Mr. G. T. Carmichael, valuation auditor, and the speaker.

Valuation Being Made by the Government—It may be well at this point to correct one or two misconceptions which seems to be general. The valuation is being made by the Federal Government, not by the carriers. No values are being placed upon the property by the field men who are only making an inventory. To date no value, even tentative, has been placed upon any railroad in the United States.

Costs—The department of valuation has a cost bureau at work studying prices, price tendencies, material centers, transportation costs, labor centers, wage rates, etc., and the carriers' organizations are making similar studies.

Construction Programme—An engineering programme must be devised to cover the logical construction of the property as to sequence and method of procedure. From this, together with the inventory of quantities, can be determined the time required to construct the property and a financial programme be made up to provide the funds.

Sequence will be governed largely by available receiving yards, which must be located on navigable water or at a junction point with some other carrier, as the road in question cannot be assumed to be in operation at the same time it is being built and, therefore, is available for transportation of men or material only as construction advances and to the extent it is completed.

A bridge opening would have to be spanned by a temporary trestle capable of conveying the heaviest commercial cars in order to get material ahead for the next bridge, unless the material for substructure, superstructure, and for the work intervening, including track material, was carted over the highway, a tote road built from the highway to the site, machinery, coal and supplies hauled in and perhaps water also, if fresh water fit for boilers was not available at the site. The only alternative would be to complete the road up to the barrier, construct the bridge complete, lay the track, then go on with the work to the next barrier, an obvious absurdity.

Typing System—The requirement of the law that each piece of property must be listed in detail was construed pretty literally at the outset and necessitated a vast amount of work, and the department saw that, in order to make progress, it would be necessary to exercise the discretion vested in them and make up types representing recurring composite units. This would eliminate detail measurements, sketches and narrative description and enable them to list the property by symbols, which can be readily classified, collected and totaled, and, later, valued by simply multiplying the cost of a composite unit by the number of units.

Appraisal Versus Inventory—Lately the department has given serious consideration to the direct application of prices in the field, covering property of minor value, and we have agreed to try out the scheme on the New Haven for buildings having a value of $300.00 or under and for appurtenances to buildings of like value.

You can readily see what it will mean in the case of furniture to be able to fix the value at once instead of having to make up a sufficiently detailed description, not only of the individual piece but of its condition, to enable some one else who never saw it to fix its value. The same is true of departures from type and minor additions, deletions and changes therein.

Final Effect of the Valuation—The greatest curiosity naturally centers around the ultimate result of the valuation and most of the controversies hinge upon that issue.

An express train was passing one of the way stations in the South when a nigger's "houn dog" took after the train. A man standing on the platform said, "George, do you suppose that fool dog expects to catch that train?" George replied, "Dat aint what's botherin' me, boss. What I's wonderin' is, what dat fool dog expects to do wid dat train, ef he does catch it." Gentlemen, many of us are in the same quandary about this valuation. We do not know just what will, or can be done with it.

Upon its completion we shall have a good set of maps and a complete knowledge of our property and the records relating thereto. The regulatory bodies will have the basic information necessary for an intelligent consideration of any problem relating to the property from any point of view, and it has compelled these bodies to make a scientific study of the transportation problem, which may prove to be its greatest benefit.

We believe the result will establish our right to live and to be accepted as an integral and an important part of the community. The question is not that of the public versus the railroads, as some people (and I regret to say some in authority) have intimated.

The 250,000 miles of railroad in this country represents 20 per cent of the business of the country and 16 per cent of the population is dependent upon it for a livelihood.

The investor in railroad securities and the employee of a railroad is not in a class apart, and the commissions are in duty bound to give the same consideration to the rights and interests of the railroads as they give to any other of the groups which go to make up the great public which they represent. But perhaps that is somewhat beside the mark.

The last few years have demonstrated pretty conclusively the community of interest between transportation and other business and that you can't prosper at the expense of the railroads. You can't prosper apart from the railroads. If prosper you do, you must prosper with the railroads.

Within the past three weeks I have heard it boldly asserted by one purporting to speak for a state commission that the act was passed to provide a vehicle that could be used to reduce rates, and that if that end was not to be attained the work should stop. You can readily imagine in what a broad, judicial frame of mind the gentleman would approach the consideration of any question brought before him.

The work is arduous and the task seems sometimes appalling, but the men engaged in the work are alive to its importance and to their responsibility, and show a commendable desire to arrive at the truth, which promises well for an equitable settlement of the economic questions involved, which shall be fair to the railroads and to the other groups forming the community which go to make up the confederation known as "The Public." So much the railroads have a right to expect. It is all they have a right to expect and fair play is all they ask.

Gentlemen, I commend to your mercy your president for his temerity in imposing this draft upon your patience, and I thank you for the courtesy that has enabled you to bear the strain which this dry recital has put upon it.

DISCUSSION.

Mr. Harte: I would like to say, bearing on this question of valuation, although not directly in connection with Mr. Ripley's paper,—valuation is a pretty difficult matter, but it is much the simpler part of the problem to determine those facts which are obvious. The amount of rails, ties, ballast, grading work on bridges and culverts, all this fairly easily can be measured up and the value determined. There will naturally be some little variation as between different parties making the measurements, and there will be some question probably as to the cost; but there really isn't anything exceedingly involved about these elements.

There is, however, a certain class of value elements, the "overhead" charges, over which at the present time there is a good deal of discussion and difference of opinion. One of the most important of these charges is the engineering, and what I want to touch upon here now is the exceeding importance of seeing that the engineering costs are properly charged. It is altogether too common a practice for an office that is handling construction and maintenance to let minor charges which really belong to specific work go to general maintenance or general office or some other "general" account.

It is far easier for Brown or Smith to so charge the day than to separate out the proportionate charges to the specific jobs, but while the charge to a particular piece of work for any one day may be small, it is surprising how much the aggregate becomes. As a result, the books show only a fraction of what they should, and there is not the evidence there should be to substantiate a claim for proper engineering allowance on old work of which there are no records. A little over a year ago the Division of Valuation, in order to get light on some points in doubt sent out a circular of questions to the railroads and to the state railroad commissions. Both parties set out their views and then the railroads as a body, and certain of the commissions, filed briefs. I want to read from that which was filed on behalf of the National Association of Railroad Commissioners. The Committee which signed it consisted of Charles E. Elmquist of Minnesota, Edward C. Niles of New Hampshire, C. B. Aitchison of Oregon, J. L. Bristow of Kansas, W. A. Shaw of Illinois, Max Thelan of California, George A. Henshaw of Oklahoma, and for the National Association they say:

"Each company, in the first instance, determines the type of bridge; and that bridge is used throughout the system where the location calls for that class of bridge, and the engineer determines that, and does not draw plans entirely for each separate bridge. Engineers have little to do with ties. Ties have been made to a certain specification for the last fifty years. The engineers have but little, if anything, to do with rails, frogs and switches, other than to point out the location for the same on the track. The same is true of track fastenings and other materials. Ballast requires but slight supervision of the engineer. Track laying and surfacing requires the supervision of an engineer. As to station building almost every road has Nos. 1, 2, 3 and 4 type of stations, which are constructed according to the probable necessities of the locality, which is determined by the operating officials. Hence, engineering is confined to the design of the original types of station, and occasionally some special design."

And again: "Where the original cost of engineering can be ascertained from the records of the company, the cost of engineering for reproduction new would be less than that amount, because of the improvement in instruments, and the advance in the science of engineering, and for the further reason that the topography of the country is better known and the art of railroad building is more highly developed."

And again: "The duty of the engineer is necessary in grading, in tunnels, bridges, trestles and culverts, particularly to determine the type or class of bridge to be used."

Further on in the brief are cited alleged percentages of cost of engineering on some of the principal railroads, which run like this: 2.6 per cent, 2.8 per cent, 1.3 per cent, 2.8 per cent, 2.5 per cent, 2.5 per cent, 1.7 per cent, 2.2 per cent. Anybody who has had experience in railroad building knows that those figures are ridiculously low and that proper engineering cannot be done for so little. The trouble is, as I said at the outset, that charges which should have been made to specific construction have gone into maintenance and into general overhead. In the cases of many of our older roads there are no records at all, and where they do exist they rarely show engineering costs and in judging of the cost of reproduction the investigators and valuators must use the records of to-day to estimate past costs.

When we realize that the contention of the National Association of Railroad Commissioners means a loss to the total value of the railroads of $160,000,000.00 for each per cent the engineering is reduced below its proper value, the importance of correct engineering accounting will be obvious.

A word about reproduction, which for some reason seems to many to be a great mystery; it is simple, plain, common sense. Mr. Guernsey, counsel for the American Telephone and Telegraph Company, suggested to a society before which he was speaking that if they wanted a building and one was offered to them, and the question of what they should pay for it came up, the first thought would be, Here is the lot, now what is it worth a front foot? It is worth so much. What's the building worth? Nice, brick building so many stories high. Built for probably so much, fair average price so much. The executive committee would say, "Why $150,000 is a pretty fair price for that building, for it would cost us $140,000 to build one like it, and it is worth $10,000 to have it now rather than wait the year it would take to build the new one." Now what they actually did was to reproduce the structure in their minds, and that is how most estimates and appraisals are made, but the chances are that in the majority of cases the estimators would say they never heard of "Reproduction new." It is exactly such a proceeding that is necessary in any valuation and unless where, as is so often the case, the utility was largely built without records of costs it is the record of to-day that must furnish the foundation on which to determine the probable conditions of the past.

A good many of you may ask what has that got to do with us? The brief from which I read was the brief of the National Association of Railroad Commissioners in support of their attitude in valuation and as you doubtless know, not only are the interstate carriers being valued by the Interstate Commerce Commission, but several of the states are also ordering valuations of intrastate utilities, and it behooves you and me and all other engineers to be exceedingly careful that our charges are properly made, so that when we come under investigation we can not merely claim, but can clearly prove by the records, that even though, as the brief of the National Association claims, there has been an improvement in instruments, the real cost of engineering is not about 2½ per cent but is nearer 7½ per cent, and that the allowance of but the first figure will deprive the railroads alone of nearly a billion dollars (actually $800,000,000) of real value.

LONG DISTANCE TELEPHONY.

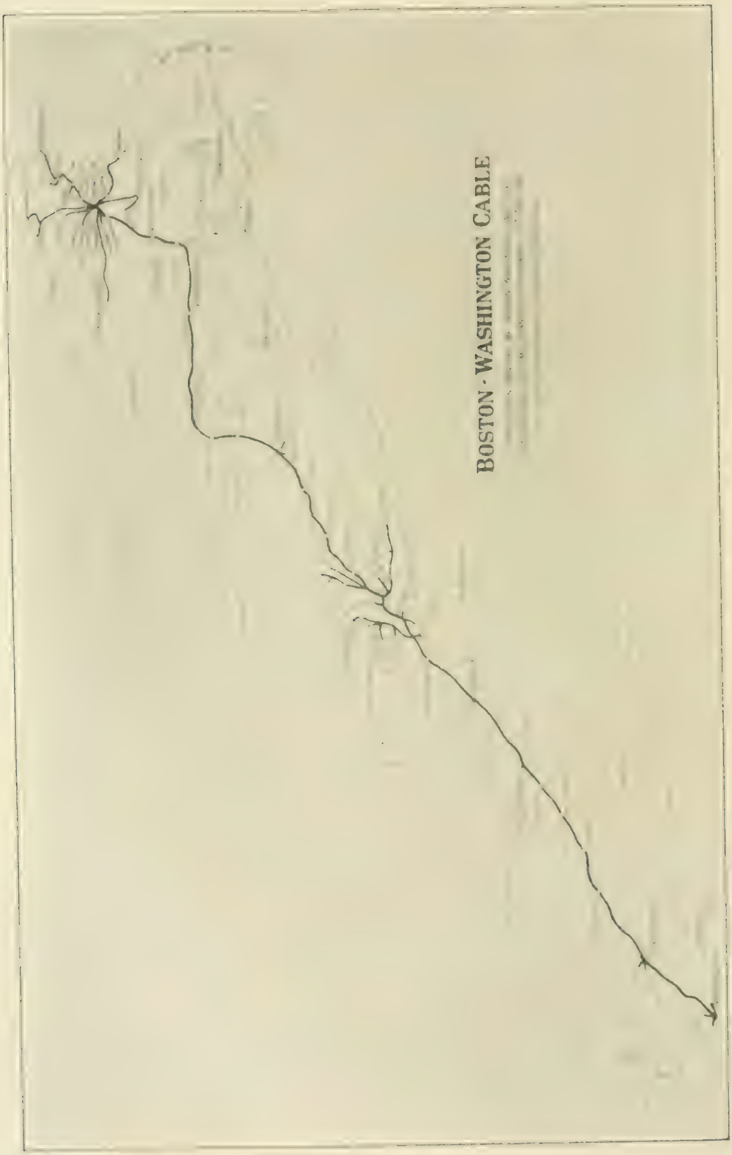
By Edward H. Everit, Mem. Conn. Soc. C. E.

The subject of this paper in effect embraces the entire Bell system with, on December 31st, 1915, some 21,000,000 miles of wire, toll and exchange, giving service to some 9,000,000 telephone stations and representing an investment of some $900,000,000, for it is the object of the management of that system to so build and maintain each and every part of its plant as to make it possible for any telephone subscriber connected with that system to talk at any time from his own telephone to any other subscriber similarly connected, regardless of whether that other subscriber is in an adjoining room, or in some other state, possibly on the other side of the continent. A telephone system has been called the nervous system of society and like the nervous system of the human body must, in order to properly do its work, reach out to the uttermost extremities. The slogan of the Bell system is "Universal Service" and this morning I propose to touch upon some of the features of giving that service.

Transcontinental telephone service not only involves the circuits connecting New York and San Francisco but also involves every other part of the telephone plan.

Broadly speaking, a complete telephone system consists of two separate and distinct parts, the local or exchange plant, and the toll plant. While in many cases poles carry both toll and exchange circuits, and cables also contain both sorts of circuits, still these circuits differ from one another in many respects, and construction that would in every respect give entirely satisfactory local service would be entirely out of place in the toll plant. In every so-called toll connection, however, parts of two local plants are involved, one at each end of the toll circuit, as well as the toll plant, so it is imperative that each element of every exchange plant be so designed as to be capable of being connected at will to the toll plant, and that the transmission losses in the exchange plant be not excessive. Still further, the entire plant must be capable of enlargement and extension from time to time as the exigencies of the business require without undue waste and cost, for a telephone plant is a living thing never the same on two consecutive days.

A civil engineer may build an enormous dam representing a tremendous outlay of money. But after the dam is built he goes away and leaves it, expecting it to last indefinitely with but little attention, and his work is judged by the permanency of the structure. Or he builds a double-track railroad with attractive stations located in various cities and villages along the right of way. He does not care what houses the patrons of that railroad live in, neither is he interested in the fact that they may move from one house to another from time to time. If the population increases and the business of the railroad builds up, the operating department can put on more trains but that does not ordinarily concern the engineer. But to the telephone engineer such changes are of great importance. His system must be so designed as to provide a separate pair of wires for practically every subscriber and these wires must be so distributed about the area covered by each exchange as to make it possible to take care of each subscriber, not only those that are or will be permanently located but those that move from one house to another from time to time. Now, of course, a new pair of wires cannot be run out from the central office each time an order for new service or for a change in location is received, so the telephone engineer must so plan the buildings, the switchboards, the conduit system and the cables as to provide for all these requirements and yet must avoid excessive costs for idle and non-earning plant. Buildings must always be so planned as to be capable of enlargement at minimum cost, without sacrificing such central office equipment as has been previously installed. The same statement applies to the central office equipment. Sufficient underground conduits are usually placed to provide for the estimated requirements along the route for, perhaps, twenty years, as the annual charges on conduits are small and the cost of enlargement is relatively great. Cables are pulled into these conduits from time to time as required. Cables are now available, suitable for short exchange circuits, having as many as 2,400 wires within the lead sheath. These cables are only about two and five-eighths inches over all in diameter and each wire within the sheath is separately



THE ROUTE OF THE BOSTON-WASHINGTON SUBWAY.

This is the longest complete underground telephone system in the world—435 miles.

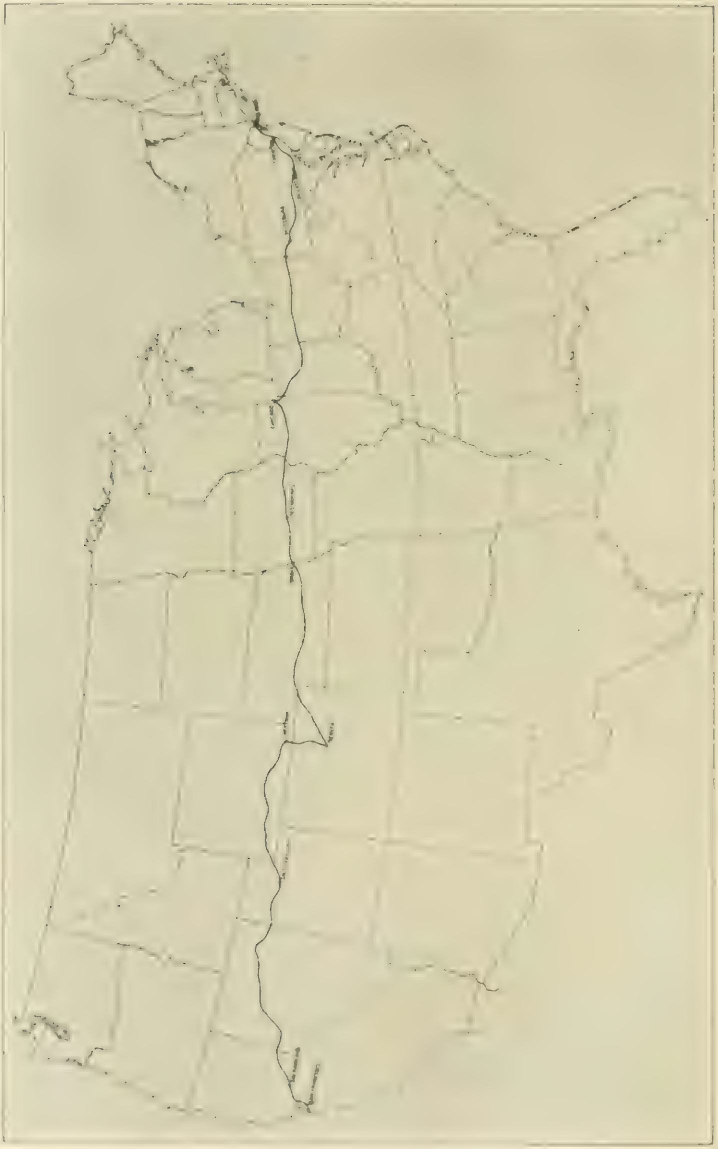
insulated from every other wire by means of a specially prepared paper.

The underground cables are extended by means of aerial cables, supported on stranded steel wire, that are similar to the underground cables but usually smaller. Beyond the area served by the aerial cables are the open wire circuits of iron wire or copper and these in turn are connected to the rubber-covered, copper-clad service wires that run into the subscriber's house and to the protector. Then comes the inside wiring, and, finally, the instrument.

The toll line plant, as well as the exchange plant, includes switchboards, cables and open wire circuits. The switchboards, while somewhat similar to the switchboards for exchange service, are specially designed to meet the more rigid requirements of toll line service. The operators have fewer circuits to attend to and their work is very different from that of the exchange operators. The conductors in the underground or aerial cables are much larger than are the conductors used for local circuits, in some cases, in the Boston-Washington cable for example, being as large as No. 10 B. & S. gauge .102 inches in diameter. The open wires, always of copper, are as large as No. 8 B. W. gauge .165 inches in diameter.

It is with such wires that the transcontinental line is constructed. Each weighs 435 pounds per mile and, as the total length of the line is about 3,400 miles, nearly 1,500 tons of copper is used for each circuit, worth at the present time nearly $750,000. There are some 130,000 poles used in the line, many of them carrying no wires except those making up the transcontinental circuits.

The telephone instrument upon your desk or wall, while apparently of the utmost simplicity, is really most marvelous. It combines two entirely separate and distinct pieces of apparatus, the transmitter which transforms sound waves into electrical waves, and the receiver which transforms electrical waves into sound waves. Still further, each complete instrument must be capable of being instantly converted from a generating station to a receiving station, or from a receiving station to a generating station, depending upon whether the user wishes to talk or to listen. One is much impressed when entering an electrical power station by the mass of machinery which it contains and



THE ROUTE OF THE TRANSCONTINENTAL LINE.
New York to San Francisco—practically 3,400 miles.

it is awe-inspiring to realize that in that station, power is generated which may be used for driving other machines, lighting houses or for heating purposes over very considerable distances. But the telephone upon your desk is also a power station and means must be provided for distributing the current which is generated by it to every other telephone connected with the Bell system regardless of where that other telephone happens to be. We know that in power distribution the object to be attained is to transmit power by means of electrical waves to some other point, but it is not necessary to worry very much about the shape of these electrical waves. In telephony, however, the shape of the wave is of the utmost importance, as otherwise the words could not be understood, so that the problem of telephony is really the transmission of electrical energy with as little destruction or deterioration of the very complex wave shape as possible, and the efficiency of telephone transmission is dependent upon two factors known as the "volume" and the "quality," "volume" referring to the loudness of the sound and "quality" to the clearness of the speech which is delivered at the distant end of the line.

The problem of transmitting speech cannot be solved by materially increasing the power at the transmitting end as can be done in many other forms of electrical distribution. We cannot fire up another boiler or start up another engine. The only motive power we have for producing the currents which we must use is the feeblest thing imaginable, a breath, that small, almost immeasurable, amount of power which is given out by the human voice, and that power must start the electrical waves, must time them and shape them so that, if the line does its part, and the transmitter and receiver do their parts, speech will be faithfully reproduced at the distant end of the line.

The telephone was born in Boston in 1876 and its fortieth birthday will be on March 16th of this year. In that same year it talked from Boston to Cambridge, two miles. On January 28th, 1878, the first commercial telephone exchange in the world was opened at New Haven, Conn. In 1882 it talked from Boston to Providence, forty-five miles; in 1884 from Boston to New York, 235 miles; in 1895 from New York to Chicago, 900 miles; in 1911 from New York to Denver, 2,100 miles; in 1913 from New York to Salt Lake City, 2,600 miles; and in 1915 from

THE WALKER-LISPENARD BUILDING IN NEW YORK.

This is the largest telephone building in the world, and contains a large amount of apparatus that is used in connection with the transcontinental line.

New York to San Francisco, 3,400 miles. Now many cities along the Pacific seaboard are within reach—Los Angeles, Portland, Seattle, etc., and the range is continually being increased. The year 1915 also saw the successful demonstration by the American Telephone and Telegraph Company of wireless telephony, and telephone engineers at Hawaii and Paris, as well as at various other far distant points, heard the voices of other telephone engineers who were talking from New York and the Government wireless station at Arlington.

Much has been said as to the possibilities and limitations of wireless telephony. Broadly speaking, the science of electrical engineering is still in its infancy and no man can tell what the future will bring forth. Still certain facts are well known and from these facts certain laws have been deduced which make it possible to determine, with a very considerable degree of accuracy, what, under certain conditions, may be expected. Based upon this knowledge it is now the opinion of those best informed upon the subject that wireless telephony will not supplant but will supplement the present wire system, and thus extend the range of telephone transmission to many points to which it would be impossible or impracticable to extend wire circuits.

It may occur to some of you to ask what great improvement in the art made the transcontinental line possible in 1915? No one thing can be pointed to as the answer to this question, for, in the words of President Theodore N. Vail, it is "the cumulative effect of improvements, great and small, in telephone, transmitter, line, cable, switchboard, and every other piece of apparatus or plant required in the transmission of speech" that made the service possible. Some of these improvements are particularly interesting, however, notably the so-called loading coil. The mathematical theory of these coils is thoroughly covered in several papers presented before various engineering societies by Dr. Michael I. Pupin, to whom patents dealing with the subject were granted in 1900, and by Dr. George A. Campbell, who had also worked on the problem. I shall not attempt to enter into a theoretical discussion of the subject at this time. Sufficient to say that the fact is established that the efficiency of long telephone circuits can be increased by inserting inductance coils in the circuit at suitable distances. The matter of spacing these inductance coils is of the utmost importance, and it is due to

PART OF THE WESTERN ELECTRIC CO.'S PLANT AT HAWTHORNE, ILLINOIS.

Practically all of the equipment and a large part of the material used by the "Bell system" is manufactured in this factory.

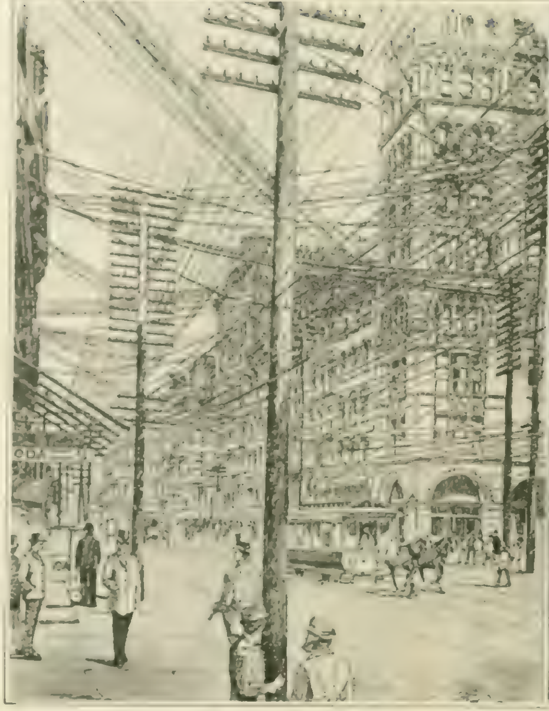
BORING A HOLE FOR A POLE IN [illegible] LAKE, NEVADA.

About 80 poles, part of the transcontinental line, were set in this lake, which runs from 18 inches to 3 feet in depth.

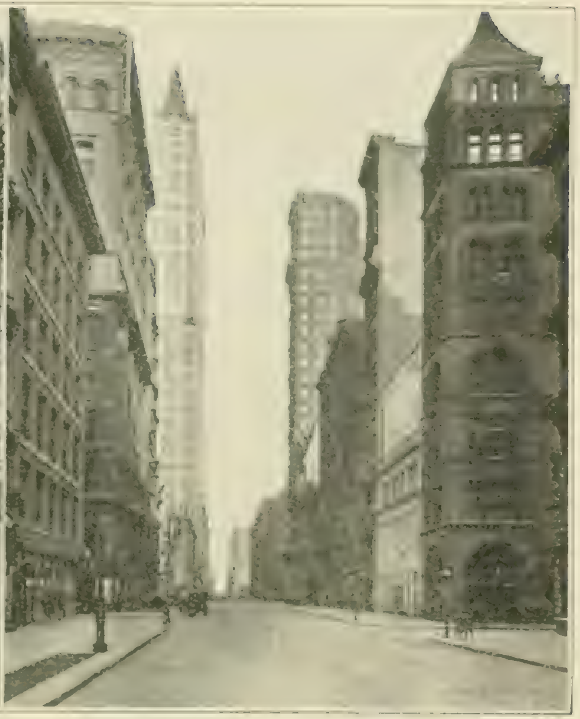
the fact that the earlier scientists who worked upon the problem failed to give this subject proper consideration, that their efforts were unsuccessful. These so-called loading coils consist of a core, shaped like a ring, made up of very fine, carefully insulated, iron wires .004 of an inch in diameter, the iron being specially selected, as it must have peculiar mechanical, electrical and magnetic qualities. Around this iron core are wound two copper wires, one for each side of the telephone circuit. These windings of copper wire are so placed that when in service each will magnetize the core in the same direction so the mutual induction will be added to the self induction. Over these windings a layer of tape is placed and then the completed coil is thoroughly dried out. After that it is immersed in a compound to keep it dry and placed in a suitable iron case for mechanical protection. It is interesting to note that in addition to the 6,800 miles of copper wire that make up each transcontinental circuit some 13,600 miles of this fine iron wire are used in the loading coils that are a part of it.

While, as stated above, Dr. Pupin's patent was granted in 1900, ways and means for successfully loading No. 8 circuits in commercial service were not evolved for several years, and it was not till 1911 we felt reasonably sure that the problem had been solved.

It was not only necessary to design the loading coils and to find out how to manufacture them, but also to materially improve the conditions in the outside plant, for it was soon found that the problem of loading No. 8 circuits was largely one of insulation. Low insulation on a loaded circuit has a much greater effect upon the efficiency of the circuit than has low insulation on an unloaded circuit, and as the efficiency of the circuit is increased, the more serious becomes the insulation problem. When one considers the fact that there are considerably more than a quarter of a million insulators used in each circuit of the transcontinental line and that, particularly in wet weather, there is some leakage at each, it is evident that the cumulative effect of any improvement in the insulation at each insulator would be of great help. So a new type of double petticoated porcelain insulator was designed and introduced into the plant. It was also found that the leakage over the braid of the rubber-covered bridle wires, which are used for connecting the loading coils to the circuits,



AN EXAMPLE OF WIRE CONGESTION AT JOHN ST. AND BROADWAY, NEW YORK, BEFORE CABLES WERE INTRODUCED.



THE SAME CORNER AFTER THE WIRES WERE PLACED IN UNDERGROUND CABLES.

was quite a serious matter, so special insulators through which the bridle wire passed were developed. Methods of transposing the circuits in order to avoid interference were also perfected as were the mechanical devices used at the transposition poles.

A device known as a telephone repeater, designed to help the feeble currents which are used along on their journey, was also developed. These repeaters are now giving very satisfactory results and are used in all of the longer telephone circuits.

The switchboards also received their share of attention, particularly in so far as the cord circuits were concerned. Each part of the plant, in fact, was most thoroughly gone over, and all the improvements which were made, great and small, did their share towards making truly long-distance telephony possible.

The great amount of plant involved in every long-distance connection makes it imperative to get as much out of the circuits as possible, so ways and means have been devised for superimposing upon two physical circuits a so-called phantom circuit. Each side of the phantom circuit consists of the two wires of one of the physical circuits, and as the current is equally divided between these two wires and flows in the same direction in each at the same time, conversation over the physical circuit is not interfered with. So out of four wires we get three telephone circuits and the earning power of the line is increased 50 per cent. Of course certain additional apparatus must be installed, and certain losses in transmission over the physical circuits due to this apparatus are inevitable, for we cannot get something for nothing; still the cost of the apparatus and the losses are relatively small. Strange as it may seem, the phantom circuits are also loaded and the transmission over the phantoms is somewhat better than over either of the physical circuits. The possibility of telegraphing over telephone circuits has also been considered and methods have been devised for doing this, so at the present time it is possible with four wires between any two points to simultaneously carry on three (3) entirely separate and distinct telephone conversations and to send eight (8) entirely separate and distinct telegraph messages.

The cables used for long distance work differ from those used in exchange work not only in the size of the conductors used but also in the manner in which the conductors are built up to form the core. Briefly, the layup provides not only for each pair of wires being twisted about itself to avoid induction between the circuits, so-called crosstalk, but also for both wires of one pair being twisted about both wires of another pair of the same size. The purpose of this special formation, a so-called quad, is to enable the four wires forming a quad to be phantomed in order to obtain three telephone cable circuits from two pair of cable conductors. The mechanical construction of these cables is extremely interesting but I will not attempt to describe it at this time.

It is customary to refer to telephone service as being instantaneous, but now we have reached out to such great distances that, from a scientific standpoint, such a statement is not strictly true. Sound waves travel at the rate of about 1,160 feet per second through the air, so it would take, if such a thing were possible, about four hours for them to get from New Haven to San Francisco. The electrical waves, traveling at the rate of 56,000 miles per second, which is the velocity possible over the transcontinental line, will reach San Francisco in about one-fifteenth of a second. If one considers the local time at New Haven and San Francisco, the sound waves, if they could travel through the air, would apparently reach San Francisco one hour after they started, but the electrical waves would apparently reach there three hours before they started. Don't forget this fact if you wish to send New Year's greetings to some friend on the Pacific coast over the transcontinental line, for if you call him up at exactly midnight on December 31st he will still have three hours, less one-fifteenth of a second, left of the old year.

THE CONSTRUCTION OF THE MORRIS DAM ADDITION TO THE WATERBURY WATER SUPPLY.

By C. L. Nord, formerly Assistant Engineer; Mem. Conn. Soc. C. E.

The water supply of the city of Waterbury has been a very difficult problem, owing to the rapid growth of that industrial city. The territory southeast of the city has been most extensively developed into watersheds, etc., by the New Haven Water Company and other public supplies. Therefore, only the territory to the north and to the west of the city was left which could possibly be developed into watersheds to give sufficient supply to care for the needs of the city.

Careful studies and investigation of this territory were made and resulted in the decision that the territory to the northwest of the city, among the hills on the west branch of the Naugatuck River, would furnish ample supply. In the year of 1893 the work was begun on the Wigwam Reservoir, which consists of a masonry dam and an earth dam with spillway. This dam is located about ten miles northwest of Waterbury and in the townships of Thomaston and Watertown. A supply of 737,000,000 gallons can be stored in this reservoir, which was sufficient for a few years, but then proved to be too small.

In the years of 1906 and 1907 the city had the problem of a water shortage to solve. In the year 1908 the water shortage became so serious that of the possible storage of 737,000,000 gallons only 240,000,000 gallons were available. This increasing seriousness of the water shortage annually made an additional water storage necessary as soon as possible. Again thorough investigations were made for a site for a new reservoir. A site just above the head of the first reservoir was found to be the most economical, practical and convenient for this purpose, and was therefore selected. Test borings to solid rock were made across the valley at once and recorded in a cross section, which showed the materials and depth encountered. The test samples were preserved for future reference for the contractor to bid on.

In December, 1908, the Board of Public Works ordered preparation of plans for a new reservoir, to be built on the selected site. The project consisted of an earth dam, having a concrete core wall and weir wall, crossing the valley at the smallest point.

The total length of dam and weir wall is about 1,100 feet. The core wall has a maximum depth of approximately 140 feet, including the foundation below the bottom of the valley. The depth of water stored is about ninety feet. The capacity of the reservoir is two billion gallons, and the water covers more than 150 acres. The principal items of the estimate of quantities were the following:

396,000 cubic yards concrete.
525,000 cubic yards rolled embankment.
9,000 cubic yards slope paving.
11,000 cubic yards loaming.

The core wall, up to a height of thirty-five feet above the top of the foundation, has a width of twelve feet, and from there on batters ⅝″ to a foot, the top being 2′ 5″ wide. The concrete up to a height of ninety-two feet above the top of the foundation is of a 1:3:6 mixture, and from there on a 1:3:5 mixture. The upstream embankment has a slope of 3:1 (to elevation 455) and then changes to a 2½:1 slope. The face of this slope is paved with quarried stones, which have an average depth of eighteen inches and which are resting upon a bed of crushed stones of twelve inch thickness. The slope of the downstream embankment is 2:1 with eight feet berms every eighteen feet in elevation. To prevent washouts eventually caused by rain storms, a drainage system is provided for the downstream side of the dam, consisting of several catch or intake basins on each berm, connected by vitrified tile pipes. The slope is loamed and sodded. The concrete weir wall is approximately 200 feet long and has on the upstream side a batter of seven to twelve inches and on the downstream side batter of one to twenty inches. The wall is faced on both sides with concrete blocks. At the end of the weir wall concrete headwalls are provided, which are also faced with concrete blocks. The intake and gate chamber of the service gate house are located in the downstream headwall.

The project includes a small masonry dam at the Morris Brook, with masonry conduit leading from this dam into the reservoir. The dam is located about 1,100 feet northwest of the main dam on the south side of the Morris road. The object of this dam is to divert the flow of the Morris Brook and deliver it into the new reservoir. This concrete dam has a total length of about 170 feet. A spillway fifty feet long is provided near the end on the south side. The intake conduit is located on the north side of the dam and is of a rectangular section five feet three inches wide and five feet deep. The roof of this conduit is eight inches thick, reinforced with trussed steel bars. The bottom has a flat section of two feet width, the sides sloping toward the walls in a 1:6 batter. The contract for this dam was let in July, 1909, to J. C. Abbot of Watertown, although the work was finished by Frank De Aurio of Waterbury.

In August, 1909, the contract for the construction of a portion of the core wall foundation of the main dam was let to the firm of A. Boss of Philadelphia, but the work was finished by the city of Waterbury. This portion extends from the road, called Valley Turnpike, at the foot of the easterly hillside, to a concrete pipe tunnel, at the foot of the westerly hillside of the valley. This pipe tunnel, which runs from the north to the south through the dam and core wall, was built to answer two purposes. The first purpose was to take care of the waters of the Slab Meadow Brook and the west branch of the Naugatuck River during the construction of the dam. The second and final purpose is the service as a pipe gallery, carrying the 30″ bottom drainpipe. The conduit or pipe tunnel is of a horseshoe section, six feet wide and six and one-half feet high, of concrete, reinforced with twisted steel rods throughout. Every ten feet, ribs projecting out six inches beyond the outer surface of the tunnel are provided for the purpose of cutting off water, which probably would flow along the top of the conduit. These ribs are provided only on the north part of the tunnel, running from the core wall to the foot of the upstream side of the dam.

At the north end of the tunnel is located the intake chamber for the bottom drain pipe, which is equipped with cast iron grating to keep objects out of the drain pipe. At this end the conduit is closed up with a reinforced concrete slab of three feet thickness, surrounding the drain pipe. At the downstream side

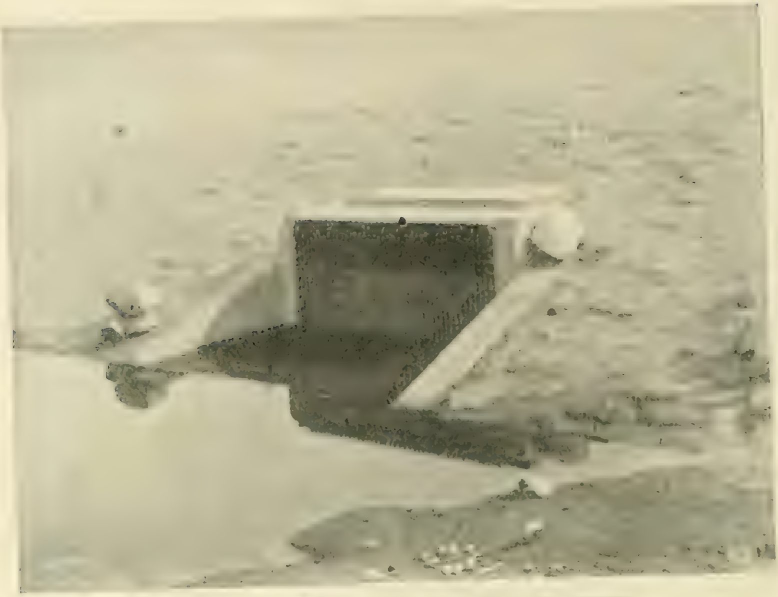


FIG. 1. INTAKE CHAMBER OF BOTTOM DRAINPIPE.

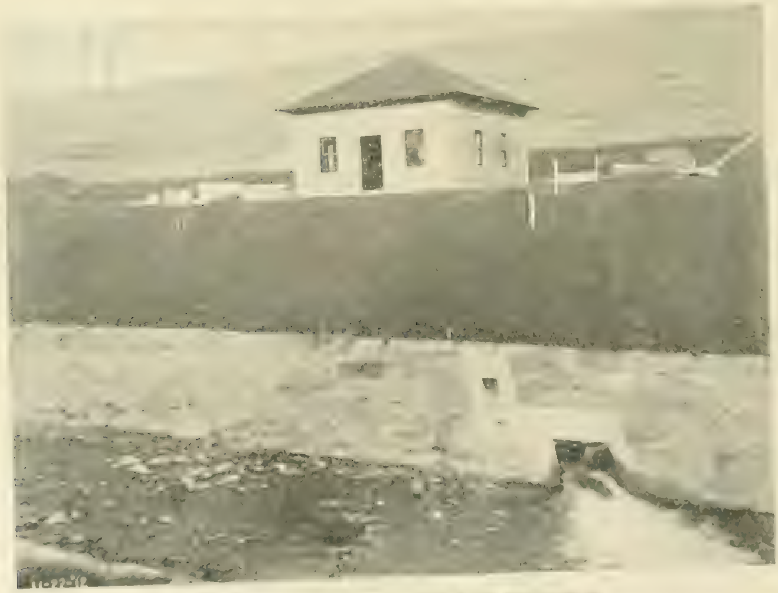


FIG. 2. DRAIN GATEHOUSE AND SPILLWAY.

of the dam the conduit ends near the toe of the dam in the drain gate house, which contains various pipes, gates, venturi meter and a small hydro-electrical plant. The conduit is a very important structure, as on its integrity and that of the core wall the safety of the dam depends and therefore received the utmost care in construction. The center line of this conduit was given a number of deflections so that the greater part of the base of the foundation could be placed on solid rock and at the same time prevent, as much as possible, heavy rock excavation.

About fifty feet of the upstream end was placed upon very coarse, firm gravel, as no ledge could be found. Here was a broad foundation, built of rubble masonry. At the downstream end, for a length of about 150 feet, also, no ledge could be found. Here the concrete invert was spread upon the gravel and reinforced throughout with heavy, twisted steel rods.

In the construction of the conduit different concrete mixtures were used, according to the location. A joint between the core wall and the conduit at the intersection was avoided, as the section of the core wall through which the conduit passes and the adjoining section of the tunnel was cast in one operation. The conduit was built by Frank De Aurio and is a very fine piece of work. The excavation for the core wall foundation of the main dam was started at a point about midway across the valley. A trench, with side slopes of 1½ to 1, was dug to a depth of fifteen feet, the width being thirty-two feet at the bottom. At this point a trench twenty-two feet in width, having interlocking steel sheeting as sides, was started. This steel sheeting was driven down to solid ledge and when the material between the sheeting was excavated the ledge was found almost exactly as shown in the cross section. A part of the material excavated was found to contain a quantity of sand. This material was screened and washed and the sand used for making concrete.

At the bottom of the trench the rock surface was found to be very seamy and made a rock excavation of a depth from five to twenty feet a necessity. The control of the ground water, which entered the trench very freely at many points at the foot of the steel sheeting, was found to be a very troublesome problem. The entering water made it practically impossible to prepare the foundation properly, nor could an impervious wall be built in running water. A comprehensive scheme was used, that of laying tile drain pipes at the bottom of the trench, on each side close to the sheeting. These pipes were laid in rubble masonry, which was built upon the ledge and led to a sump, from which the water was constantly pumped. Wherever a stream of water was found entering the trench, a Y was set to receive the flow. Under this method the trench was entirely freed from water and the core wall foundation was started, a section at a time, under the best possible conditions, which made a water-tight joint between the concrete and the bedrock. The concrete was mixed on top of the sheeting and lowered into the trench by buckets.

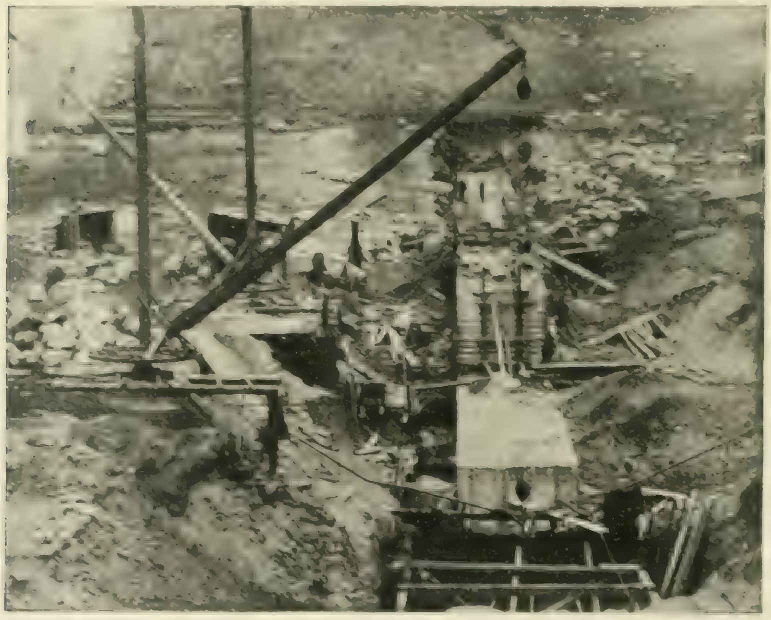


FIG. 3. COREWALL FOUNDATION SHOWING SHEET PILING.

At the bottom of the trench the core wall foundation extends the whole width of the trench, against the steel sheeting, for a height of two feet. This formed a substantial support for the steel sheeting after the lower braces had been removed and also gave a broad and solid base for the core wall. On this base the core wall is built, having a width of twelve feet, until the original surface of the ground was reached. The steel sheeting was left in place, in order not to disturb the ground, which would be the case if the sheeting had been removed. The space between the concrete core wall and the steel sheeting was filled in with hardpan, in very thin, horizontal layers and rammed solid.

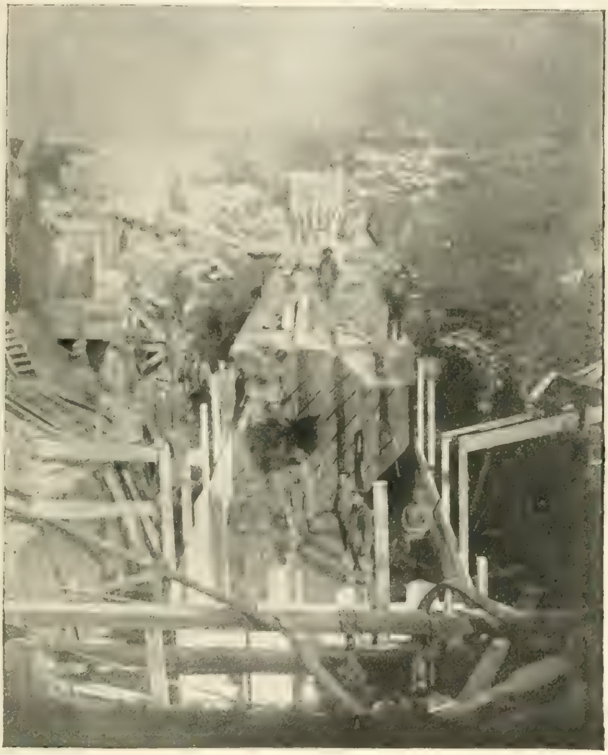


FIG. 4. COREWALL FOUNDATION.

About 75 per cent of the concrete work was done in severe winter weather, as it was of utmost importance to complete this work before the time of the usual spring floods. To accomplish this the work was carried on practically day and night. The material for the concrete, as sand, gravel stones and water, was heated. After placing the concrete, the work was covered with canvas. As the depth of the trench was approximately fifty feet deep, there was very little danger of freezing even in severe zero weather. To keep the waters of the Slab Meadow Brook and of the west branch of the Naugatuck River off the dam site, while the foundation work was in progress, a temporary dam was built on the upstream side at the end of the conduit, through which the water was led into the spillway channel of the dam, which ends in the Wigwam Reservoir. A temporary dam was also built on the downstream side of the dam.

A heavy flood occurred in the spring of 1910. The conduit could not take all the water; it rose over the temporary dam and flooded the core wall trench, doing no damage whatever, except delaying the work for about a week. During the same winter the excavation for the weir and head walls foundation was begun. This work was not very difficult, as the rock was practically at the surface and required only excavation to solid bed rock, after the proper lines and grades were reached.

In June, 1910, the work of building the main part of the dam was begun by the Ryan, Unmack Company, of New Haven, Conn. Although a considerable amount of earth filling was done and some concrete laid during that summer and fall, the greater part of that season was spent in organizing and securing proper equipments for the purpose of proper prosecution of the work. A Ligerwood cable way was erected, with a power station on the top of the westerly hill. At the foot of the west cable way tower the concrete mixing plant and a cement storehouse were located. A pile trestle was built, running from the north end of the westerly hill toward the south, along the side of the cement storehouse, ending at the concrete mixing platform. This trestle was used for transporting the sand which was required for making concrete, and which was excavated from the bottom of the valley. North of the cable way tower the stone crusher and the crushed stone storage bins were located, also an elevated water storage tank, from which the water was furnished for the construction of the dam. The stone quarry, in which good coarse granite was found, was located west, in back of the stone crusher. The stones, after being quarried, were transported to the stone crusher and there crushed. All the crusher dust was effectively screened out and separated from the stones, all particles over one-eighth of one inch passing through as dust. For a concrete mixture of 1:3:6 all crushed stones passing through a

2″ screen were used. For a concrete mixture of 1:3:5 all stones passing through a 1½″ screen were used, while in a 1:2:4 mixture only a 1″ crusher run was allowed.

The sand which was used in making the concrete was found in the bottom of the valley on the upstream side of the dam. The sand was well graded and sharp, but required thorough washing, as it contained a large amount of silt. The sand was dredged by means of orange peel buckets, which were emptied over the washing tower. This tower was equipped with two screens, which sloped in different directions, one below the other. The sand had to pass over these screens before reaching the washing box and all gravel stones were separated thereby from the sand. The washing was accomplished by feeding the sand slowly into the washing box, which had at the bottom a series of perforated steel water pipes, through which water was forced by means of a duplex pump, separating the silt from the sand. The waste water containing the silt flowed over into a settling basin and the washed sand passed through a valve into a one and one-quarter yard dump cart. This dump cart, running on rails, was transported to the north end of the foot of the westerly hill, and here, by means of a derrick, hoisted to the top. Over the before-mentioned trestle, the sand now was transported to the concrete mixing platform or the storage pile. The washed sand was tested daily in the city laboratory and contained about 5 per cent of silt and had an average coefficient of 4,155.

In the spring of 1911 the contractors' plant was very well organized and the work began in March. The core wall was built in sections from twenty to thirty feet long and about five feet high. The forms of such a section consisted of panels, made of 2″ planed lumber, with 4:4″ uprights, about three feet on centers and one or two bulkheads. The forms were braced from the outside by timber braces and were drawn together on the inside by means of twisted wires. The wires were fastened on each end to a hook bolt, which was screwed into iron blocks. In these blocks other bolts were screwed, extending through the forms and stringers, which were firmly held by washers and nuts. Before filling the forms with concrete, they were scraped and cleaned and painted with soft soapsuds of paraffine oil.

In order to secure a water-tight bond, when new concrete was placed upon old, the surface of the old concrete was picked

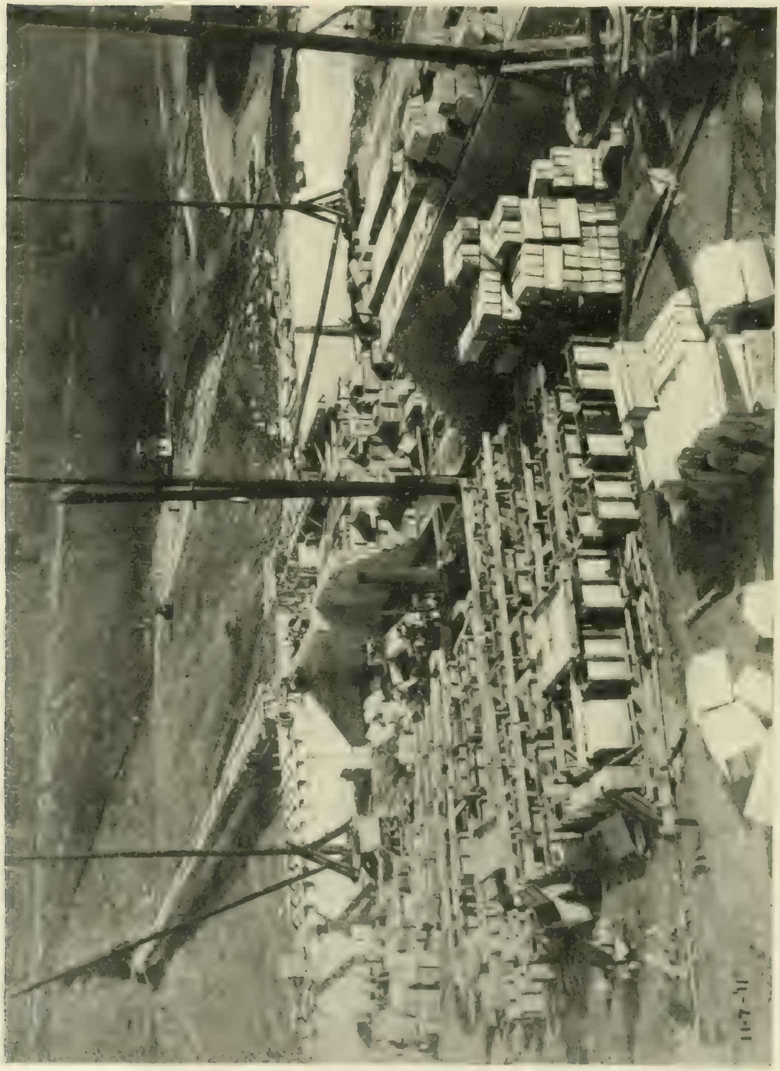


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FIG. 5. DAM LOOKING EAST, BLOCKYARD IN FOREGROUND.

and thoroughly washed. A layer of cement grout one inch thick was spread. The new concrete was placed in layers about six inches thick and was so soft, that the man placing the concrete sank into it, about up to his ankles. Great care was exercised that not too much water should accumulate in the forms.

The concrete was spaded along the forms. A long handle, ordinary garden spade was used for that purpose and was pushed down between concrete and the form, with the back toward it, thus keeping all stones away from the face of the wall and allowing the fine mortar of the concrete to run in back of the spade. By this method the wall had a very smooth face and no stone nests were ever found after the forms were removed. A limited number of sound, clean, quarried stones were permitted as plums in all mass concrete. If such plums were used, they had to be placed at least twelve inches from the outside of the wall and twelve inches apart. Such plums were worked into the soft concrete until a good bed was assured.

To secure good bonding for vertical joints and to take care of any temperature stresses during construction, one inch twisted steel rods eight feet long were placed in the ends of each section, four feet incased in the concrete of the section under construction and four feet projecting out, to be incased in the concrete of the next section. Furthermore, in the end and top of each core wall section six inch triangular niches were provided. After the concrete in the forms had sufficiently set, the forms were removed, the bolt holes filled with cement and the face of the wall given a double coat of cement wash. The top of such sections was covered with burlap bags hanging down at the sides and kept constantly moist. The niches on top of the wall were filled with water. The weir and head walls were built simultaneously with the core wall. The weir wall was built of solid concrete and faced with concrete blocks on both sides. The construction was carried out in the following manner: First a course of concrete blocks, with header blocks, was laid, followed by a course of stretcher blocks. Forms were set up running parallel to the face of the wall and about six inches from the end of the header block and filled with concrete to the top of the stretcher course. Two more courses of concrete blocks were laid and then the space between the blocks was filled with concrete. The weir wall was built similar to the core wall, in sections.

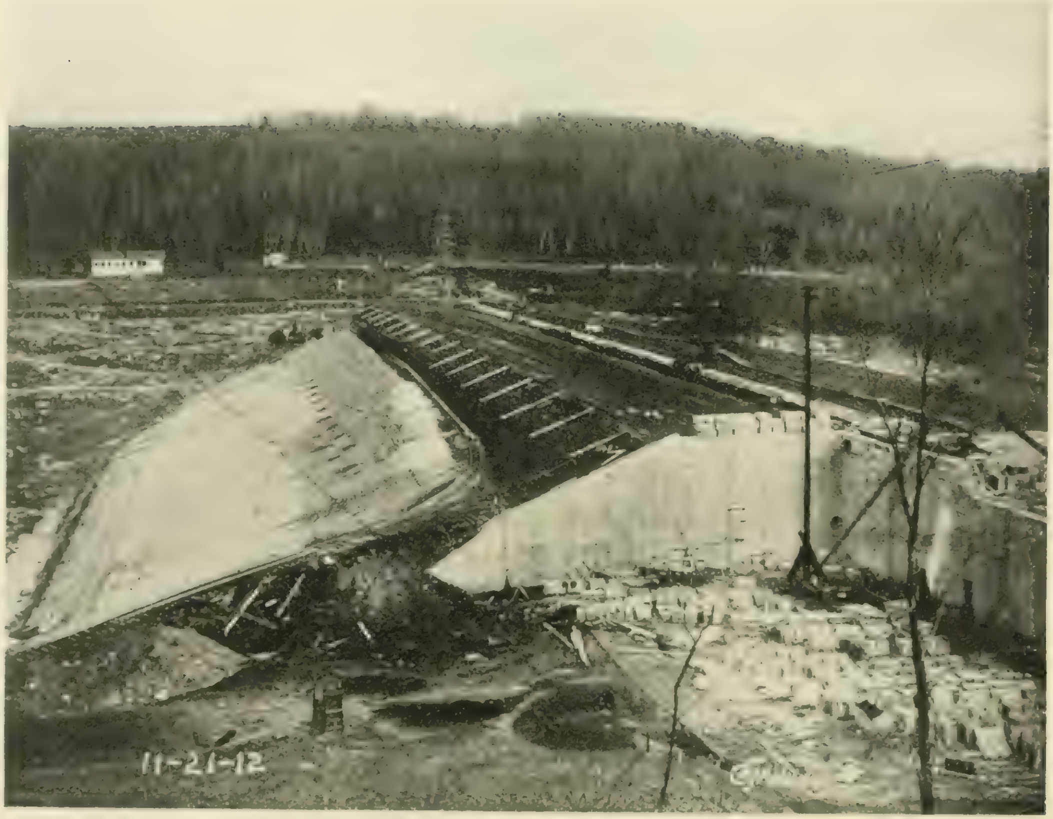


FIG. 6. DOWN STREAM SLOPE SHOWING PAVING AND CONSTRUCTION R. R.

The utmost care was exercised to secure good bonds and water-tight joints. Niches of about 4:4′ provided at the bulkheads and slots of about eighteen inches in depth and four feet in width were left on top of each section, to assure good bonding, giving a good hold for the next following section. The concrete head walls were built in practically the same manner, but as they had only one concrete block face, forms were used for the back side of those walls. The concrete blocks, which were used for facing the weir and head walls, were made of a 1:3:5 concrete mixture, with the exception of so-called special blocks, which were made of a richer mixture. All those blocks were cast in wooden forms. The forms were made of two-inch planed lumber, with 4:4″ posts. The sides were drawn together at the top by three-eighths inch round bolts, about two feet long, and at the bottom by double wedges.

Substantial forms were necessary, as warping of the forms would make a block useless for its original purpose. To produce blocks with a perfectly smooth face, the forms were lined with a round edge sheet iron face plate. Before casting the concrete blocks, the forms were painted on the inside with paraffine oil to avoid adhering. There were many differently battered and shaped blocks made. A special type of blocks were the coping blocks, which were used for topping off the head walls. These blocks had two faces and the forms for such blocks were set up at an angle of about 45 degrees, so as to have the weight of the concrete press against both faces. It had been found out by experience that the pressure of the concrete upon the sheet iron face plate helped a great deal to produce a perfectly smooth face.

Great care was exercised in making, storing and handling the concrete blocks. The finished blocks were stored to cure, covered with burlap or canvas and kept constantly moist. Imperfect blocks were used to a great extent as plums in mass concrete. Such blocks were perfectly sound, but had probably a slight defect in the face, as air holes, etc., or were out of shape, so that they could not be used for facing the walls. About 2:2″ slots were provided in the sides and top of the blocks to assure a good bonding, when set in the walls. All blocks were set in cement mortar, the joint being one-half inch thick. After the blocks were set, the slots in the sides were filled with cement mortar and later pointed to the round edge of the face.

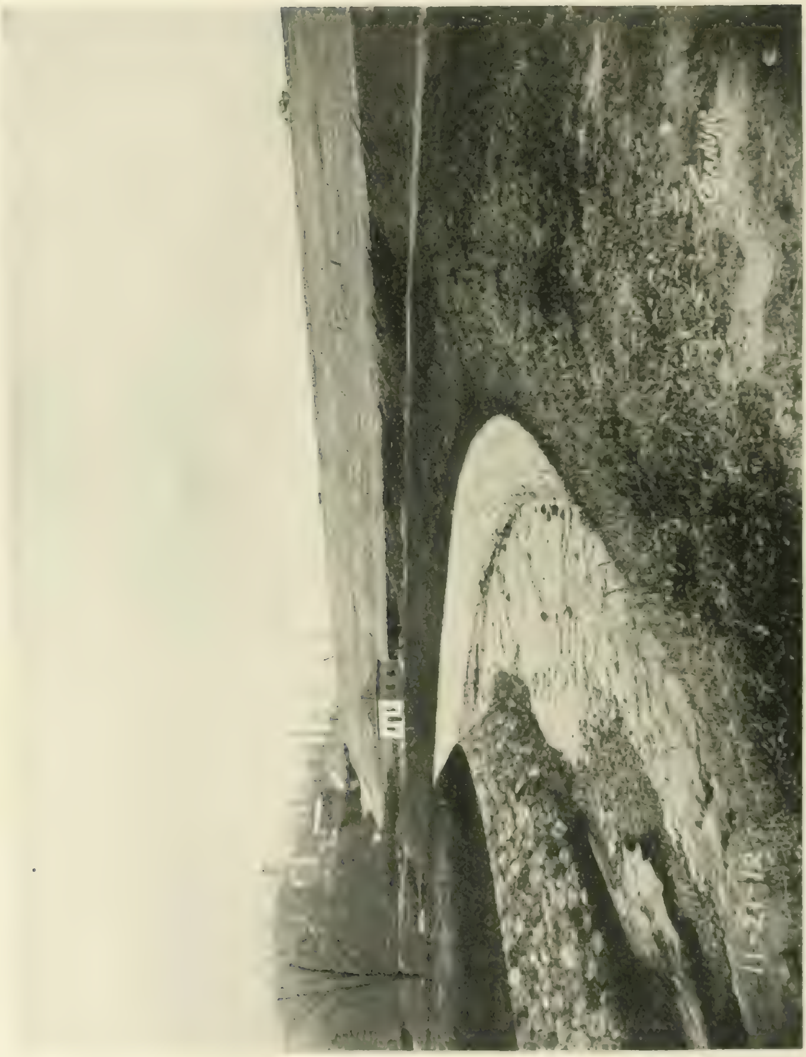


FIG. 7. DAM NEARLY FINISHED LOOKING WEST.

The concrete work of the core and head walls was carried out in such a manner that the walls never were built higher than five feet above the top of the embankment on the upstream side of the dam, while the embankment on the downstream side of the dam was allowed to be eight feet below the top of the highest section of the core wall. A very good heavy clay and blue hardpan was used for the embankment and was found only a short distance away from the dam site. The excavation of the clay and hardpan was done by a thirty-five-ton Boston and a seventy-ton Bacyrus steam shovel, which loaded it into four-yard railway dump cars. Trains of eight dump cars were drawn by Vulkan locomotives to the dam. At the dam site the cars were dumped and the material was spread in layers six inches thick on the upstream side and eight inches thick on the downstream side. The spreading and leveling was done by means of four horse-drawn road scrapers and by hand labor. All stones over six inches in diameter were removed, also all roots and sod, which occasionally happened to be in the material for the embankment. After a layer was properly spread, the tracks were pulled a few feet to one side by several teams of horses to make room for the next train to dump.

Ten-ton steam rollers were used in rolling down the embankment. The steam rollers were especially designed for that purpose and were equipped with diagonal cleats on the two rear wheels, while the front wheel was grooved. In places where it was impossible to use the rollers effectively, hand ramming was done. Before placing each layer, the embankment was wet down by an ordinary sprinkling cart, to assure bonding of the different layers and so making the embankment one solid mass.

On the upstream side a 3:3 foot footing stone of 1:3:6 concrete was laid. The footing stone has the purpose to prevent sliding of the embankment. This side was at once properly trimmed to grade and covered with a twelve inch layer of crushed stone, which served as the bed for the slope paving. The paving was done with sound quarried stones, which did not exceed three feet in length and twenty inches in depth. Into all joints crushed stones were rammed by means of crowbars. All irregular spaces were filled out with spawls not less than twelve inches in depth.

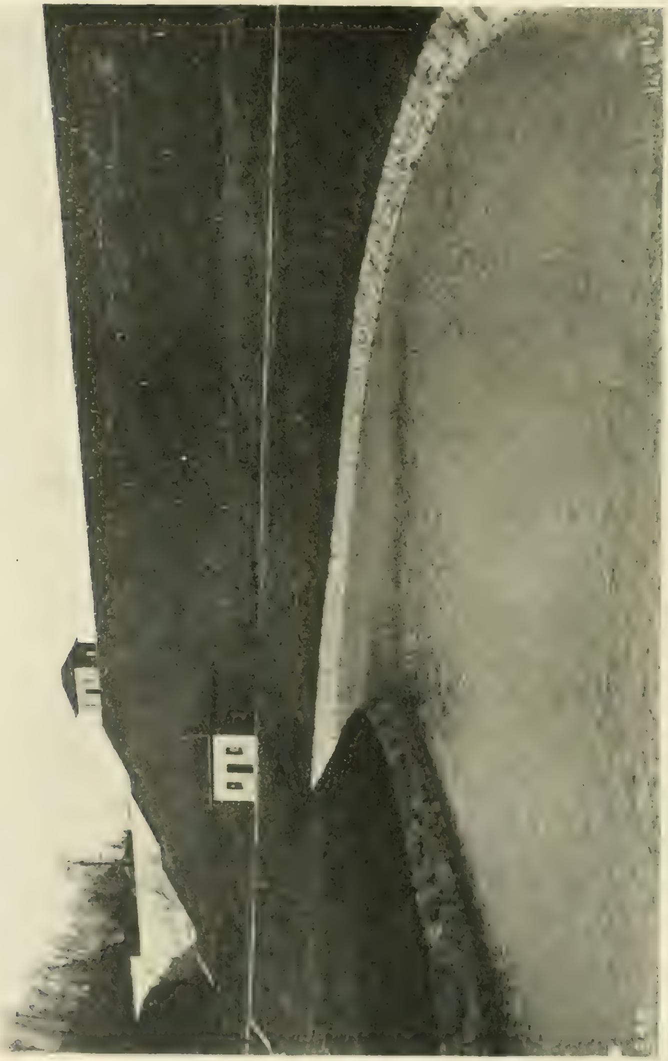


FIG. 8.

After laying the paving blocks and filling the joints, crusher dust was spread and broomed, by means of wire brooms, into all joints and crevices, which could not be filled otherwise. This method prevents any washing of the upstream embankment by the action of the waves, which otherwise would occur.

The setting of the paving stones was done by a traveling steam derrick, especially rigged up for that purpose and mounted on a platform provided with wheels, which ran on heavy rails. These rails were laid on timber horses, which were placed upon the previously laid paving and fitted the slope. A section of paving, as long as the boom of the derrick would permit, was laid and then the derrick was moved ahead. On the top or crest of the dam, east of the spillway and between both head walls, the service gate house is located. This gate house is provided with two intake wells, which have 6-30″ inlet pipes at different elevations, about every ten feet in elevation. The chambers are divided in two by copper screens, through which the water has to pass before it passes through the outlet pipes and is discharged on the face of the weir wall.

The water discharged on the face of the weir wall is let through the spillway channel into the wigwam reservoir and has a splendid ariation before entering the same. Two thirty inch pipes are laid from the screen chambers to the gate house chamber, in the downstream head wall. Here the pipes are reduced to a 24″ pipe line, which connects with the city main at the drain gate house. In the gate house chamber four 24″ gate valves are installed, one for a 24″ blow-off, which discharges into the spillway channel.

A bronze plate, giving direction how to disconnect the pipe line, for the purpose of removing a gate, etc., if necessary, is set into the east wall of the gate chamber. The drain gate house is located at the toe of the dam on the downstream side and about midway of the whole length of the dam. The 30″ bottom drain pipe enters the gate house through the conduit under the dam and connects here with the 24″ pipe line from the gate chamber and the city main. The connection to the city main is accomplished by means of a 24″ Y, of which one branch serves as a blow-off. A venturi meter is also installed. The gate house and the pipe tunnel is equipped with an electric lighting system. The current is generated by a small hydro-electric plant, installed in the drain gate house.

The whole basin of the reservoir is stripped. All loam is taken off to a depth of about eight inches and removed to a place on the north end of the reservoir, above the highest water level. All trees and roots, etc., were grubbed out before the stripping of the basin was begun. The stripping was accomplished by hand labor. The sod and loam were loaded into four-yard railroad dump cars and brought to the north end of the valley. Here the cars were pulled over an inclined track to the top of a hill, where the soil was dumped. A quantity of the soil stripped was used for loaming the downstream side of the dam and also for filling and grading the land in front of the dam. The contract for stripping the basin was let to Carlo Bianki of Framingham, Mass., while the contract for pulling the tree stumps was let to Frank De Aurio of Waterbury. The stumps were pulled by means of a Giant stump puller; no blasting of stumps was allowed, except in special cases, with the permission of the engineer.

The sanitary control of the works during construction was no small task. At the beginning of the construction of the dam, all labor camps were located below the Wigwam dam, about a mile and one-half away from the works. But soon it was found that a proper sanitary control was practically impossible, besides it was inconvenient, as the men had to travel too far before and after their day's work. Therefore the camps were later located a few hundred feet away from the dam site and a most rigid sanitary control was established and carried out. The camps and closets, etc., about the work were inspected daily by a special inspector, and no serious sickness ever developed.

The Morris dam is the biggest earth dam in the eastern section of the United States and a beautiful piece of engineering work all through. The clever and most scientific investigation for the dam site, the design which was worked out to the smallest detail, points of economy and construction, and the chief supervising is the work of Mr. R. A. Cairns, C. E., City Engineer of the city of Waterbury, Mem. Am. Soc. C. E. Great honor also must be paid to Mr. Charles W. Eddy, C. E., resident engineer.

REMARKS ON RIVER AND HARBOR IMPROVEMENT BY THE UNITED STATES IN THE CONNECTICUT DISTRICT.

By G. E. Verrill, U. S. Assistant Engineer.

As most of you doubtless know, the United States river and harbor work is done under the supervision of the Chief of Engineers of the United States Army. This method was probably originally adopted because at that time the Corps of Engineers was the only body of trained engineers that was readily available. It is also likely that the relation between the improvement of the rivers and harbors and the plans for their defense may have had something to do with the placing of this work under the Corps of Engineers. At any rate, this plan was adopted at a very early date in the history of the country.

For the purpose of carrying out this scheme the country is divided into nine divisions, each in charge of a division engineer, generally with the rank of Colonel. Each division is again divided into districts of which there are fifty-four in the whole country.

The Connecticut, or New London District, is in the Northeastern Division and comprises all the river and harbor works in Connecticut, and also the Connecticut River from Hartford to Holyoke, Mass., which is as far as it is navigable, and the Pawcatuck River, between Connecticut and Rhode Island. In this district there are at present twenty different projects for the improvement of rivers and harbors, namely:

1 Pawcatuck River, R. I., and Conn.
2 Harbor at Stonington, Conn.
3 Mystic River, Conn.
4 New London Harbor, Conn.
5 Thames River, Conn.
6 Connecticut River, above Hartford, Conn.
7 Connecticut River, below Hartford, Conn.

8 Harbor of Refuge, Duck Island Harbor, Conn.
9 Branford Harbor, Conn.
10 New Haven Harbor, Conn.
11 Breakwaters at New Haven, Conn.
12 Milford Harbor, Conn.
13 Housatonic River, Conn.
14 Bridgeport Harbor, Conn.
15 Norwalk Harbor, Conn.
16 Fivemile River Harbor, Conn.
17 Stamford Harbor, Conn.
18 Southport Harbor, Conn.
19 Greenwich Harbor, Conn.
20 Westport Harbor and Saugatuck River, Conn.

Most of these projects have been completed so far as new work is concerned, and until additional work is authorized by Congress they are in a status of maintenance; but in some cases, like the Connecticut River below Hartford, this involves considerable work each year. Others, like some of the harbors, only require maintenance work occasionally. In the case of about one-third of them, new projects for their further improvement have been recommended by the Engineer Department and are now before Congress.

In addition to the waterways named above, four others, namely:

Eightmile River, Conn.,
Clinton Harbor, Conn.,
Harbor at Wilsons Point, Conn.,
Cos Cob Harbor and Mianus River, Conn.,

have in the past been under improvement, but are not now considered as "live" projects as their maintenance is not attempted by the United States.

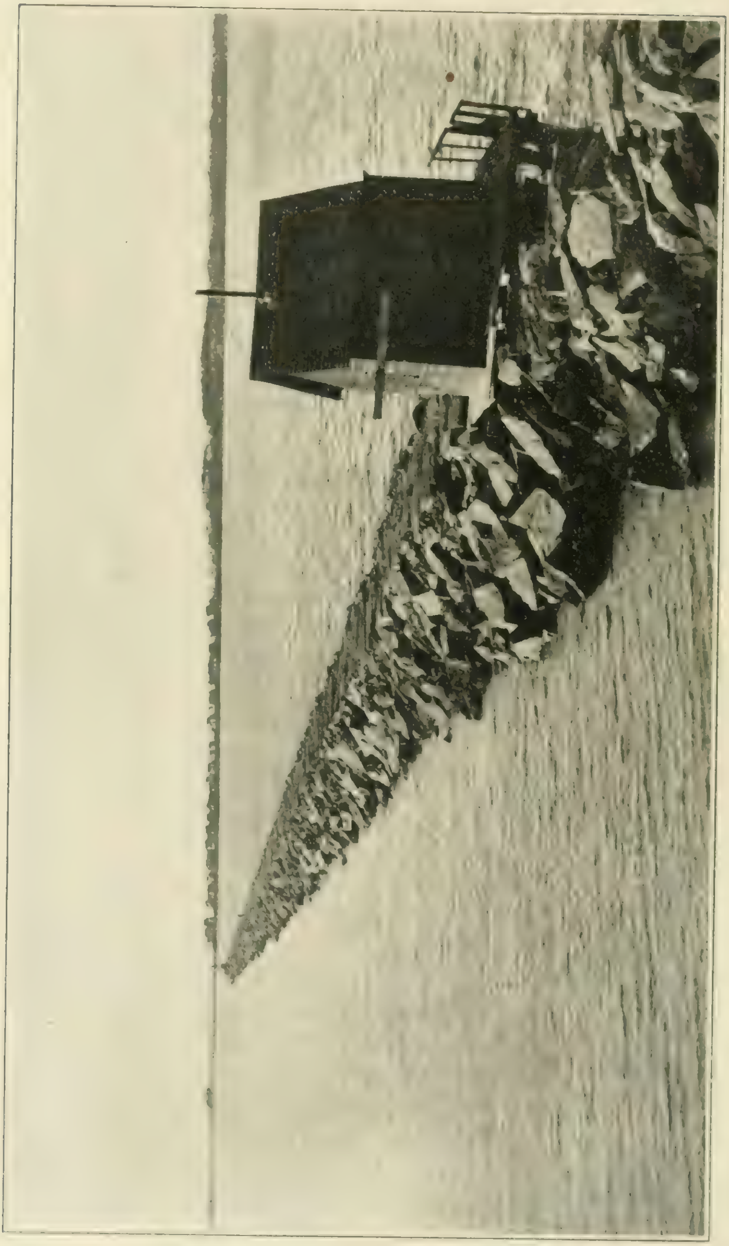
Each Engineer District is in charge of a District Engineer Officer, who is also a disbursing officer, and whose rank depends upon the importance of the work in the district, and to some extent upon the officers available, the Corps often being short of officers. Each District Officer has as many engineer assistants as may be necessary. These assistants are usually civilians, although officers of the Engineer Corps are frequently detailed for this work. The civilian assistants come under the Civil Service law and are rated as Assistant Engineers, Junior Engineers, Surveyors, Surveymen, Inspectors, etc. Assistant

Engineers are appointed only by promotion, usually from the grade of Junior Engineer: to be eligible for such promotion they must have passed a competitive examination and be eligible for full membership in the American Society Civil Engineers. They need not necessarily be members, although most of them are. Junior Engineers must now have passed a competitive examination, before they can be appointed, although formerly a diploma from an approved technical school was accepted, after at least a year's satisfactory service in the Engineer Department, in lieu of an examination.

In addition to the Division Engineers and District Officers there is also a board of five engineer officers of high rank, known as the Board of Engineers for Rivers and Harbors, whose duty it is to review all plans for the improvement of rivers and harbors, and to make recommendations regarding them.

At the head of the whole Engineer Department is the Chief of Engineers, with the rank of Brigadier General, who reports directly to the Secretary of War.

It should be clearly understood that the first move toward the improvement of a river or harbor cannot come from the Engineers, but must originate with Congress, which in turn is urged to action by the people directly interested. If the people of a locality desire to have a waterway improved they must first, through their representative or senator, usually the former, have an item inserted in the river and harbor bill calling for an examination with reference to the improvement, either in general terms or stating specifically the work desired. There is usually no difficulty in having such items inserted. After the bill becomes a law, the duty of making a preliminary examination is assigned by the Chief of Engineers to the District Officer in whose district the waterway under consideration is located. The preliminary examination consists in obtaining general information with regard to the waterway, such as the location, general characteristics, the commerce, the improvement desired, etc. Frequently a public hearing is held, at which all interested are given an opportunity to express their views. The preliminary examination does not include a survey or estimates; no field work is usually required, except in the nature of a reconnaissance, and the expense is small, frequently only nominal. In his report on the preliminary examination, the District Officer gives



HARBOR OF REFUGE AT DUCK ISLAND, CONN.

the information obtained and expresses his opinion as to whether the improvement desired is such as to warrant making a regular survey, and if so, submits an estimate of the cost.

This report is submitted, through the Division Engineer, to the Chief of Engineers. The Division Engineer expresses his opinion and it is then reviewed by the Board of Engineers. If the opinion of the Board is unfavorable, all interested parties are given an opportunity to present directly to that body further arguments or reasons for the improvement. After the Board has arrived at its final conclusion, the report, with the indorsements of the Division Engineer and the Board, and the records of the hearings, if any, go to the Chief of Engineers, who decides whether or not the survey is justified. If it is decided that a survey is not justified, the report is transmitted to the Secretary of War and by him to Congress, and the matter is ended, at least until another examination is ordered by Congress. If the Chief decides a survey is warranted the District Officer is directed to make it, and a sum of money is allotted to cover the cost of the survey.

The survey is much more elaborate than the preliminary examination. It usually requires field work, often quite extensive, the preparation of maps, tables and other data, and a careful report giving the information acquired with estimates of the cost of the work. In this report the District Officer expresses his opinion, with his reasons therefor, as to whether or not the waterway is worthy of improvement by the United States. If he thinks it is, he submits a project for the improvement with an estimate of the first cost and subsequent maintenance.

This report, like the report on the preliminary examination, is reviewed by the Division Engineer and the Board of Engineers, and finally by the Chief, who transmits it to the Secretary of War, by whom it is placed before Congress. If the final report is favorable it is then up to Congress, if it sees fit, to appropriate funds for the work.

Nowadays, Congress never appropriates money for a project that has not received the approval of the Engineers. I may here remark that both in the case of the preliminary examination and the survey, the Chief of Engineers usually concurs in the views of the Board of Engineers for Rivers and Harbors, but the Board frequently does not concur in the views of the Division

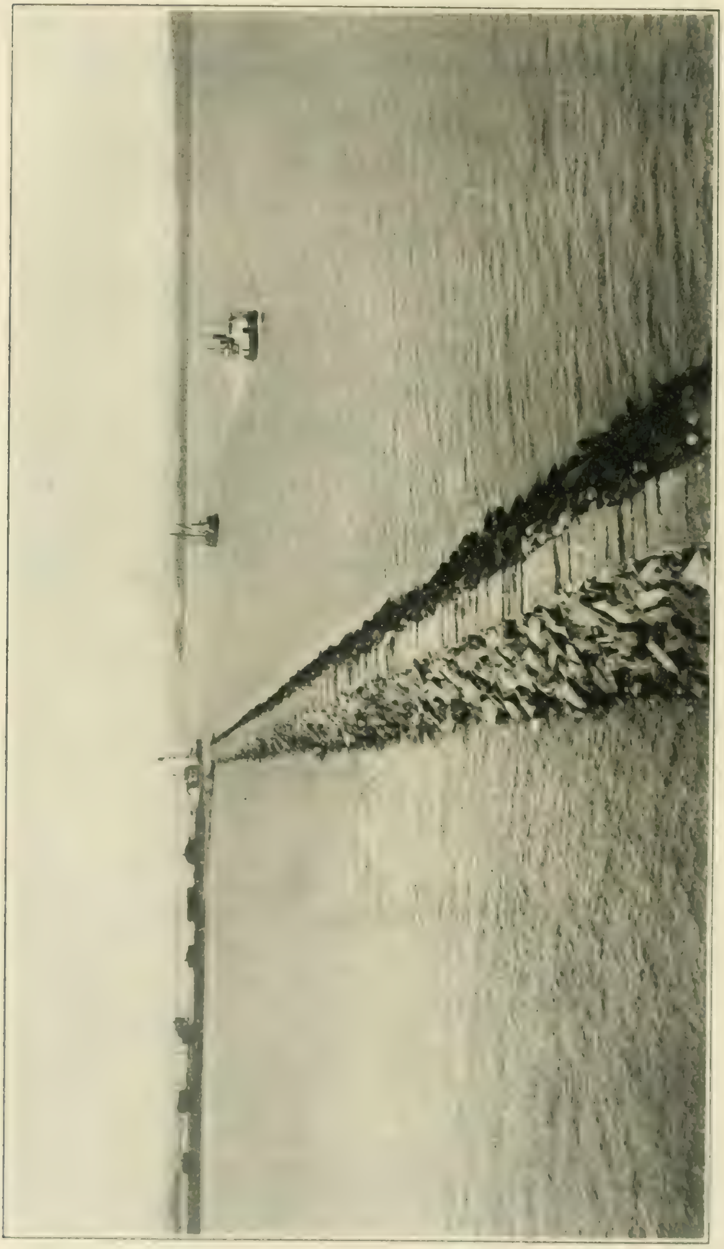
WEST JETTY AT MOUTH OF CONNECTICUT RIVER.

FAYERWEATHER ISLAND BREAKWATER, BLACK ROCK HARBOR, CONN.

Engineer or the District Officer; and the Division Engineer often disagrees with the District Officer. It is also a common occurrence for the Board or the Division Engineer, or both, to recommend modifications in the project or estimates of the District Officer. I mention this to show that the various reviews are not merely perfunctory, but are made with much care and deliberation.

After the report has reached Congress the Engineers can do absolutely nothing further until an appropriation is made, and it frequently happens that no money is ever appropriated for a project that has received the approval of the Engineer authorities; or appropriations may be made for only a portion of the project. You will readily understand from what I have said that any scheme for river and harbor improvement has pretty hard sledding before work is actually begun; and inasmuch as the same Board of Engineers reviews all projects, and as the greatest reliance is placed on its recommendations, there is very little chance indeed of any locality or section of the country being unduly favored or discriminated against. It is also apparent, I think, that there is very little truth in the talk we hear of "pork." There may have been before the present methods were adopted, but not now.

Until quite recently, no well defined plan for making appropriations for river and harbor improvements was followed. The bills were not introduced with any great regularity, and even when introduced, they sometimes failed to pass or were vetoed by the President, so that there were sometimes two or more years without appropriations. It was also customary in many cases to provide for a project by a number of small appropriations, made from time to time, in different bills, the amount and frequency of the appropriations depending to a considerable extent upon the persuasive powers of the Congressman from the state or district concerned. The result was that money for even a comparatively small project was often divided up into a number of small appropriations covering a number of years, and that if for any reason a river and harbor bill failed to become a law the work in hand sometimes suffered badly. This system also increased the cost of the work, as it was done in small pieces, and the public frequently received little or no benefit for years after a project was begun.



WEST JETTY AT MOUTH OF CONNECTICUT RIVER.

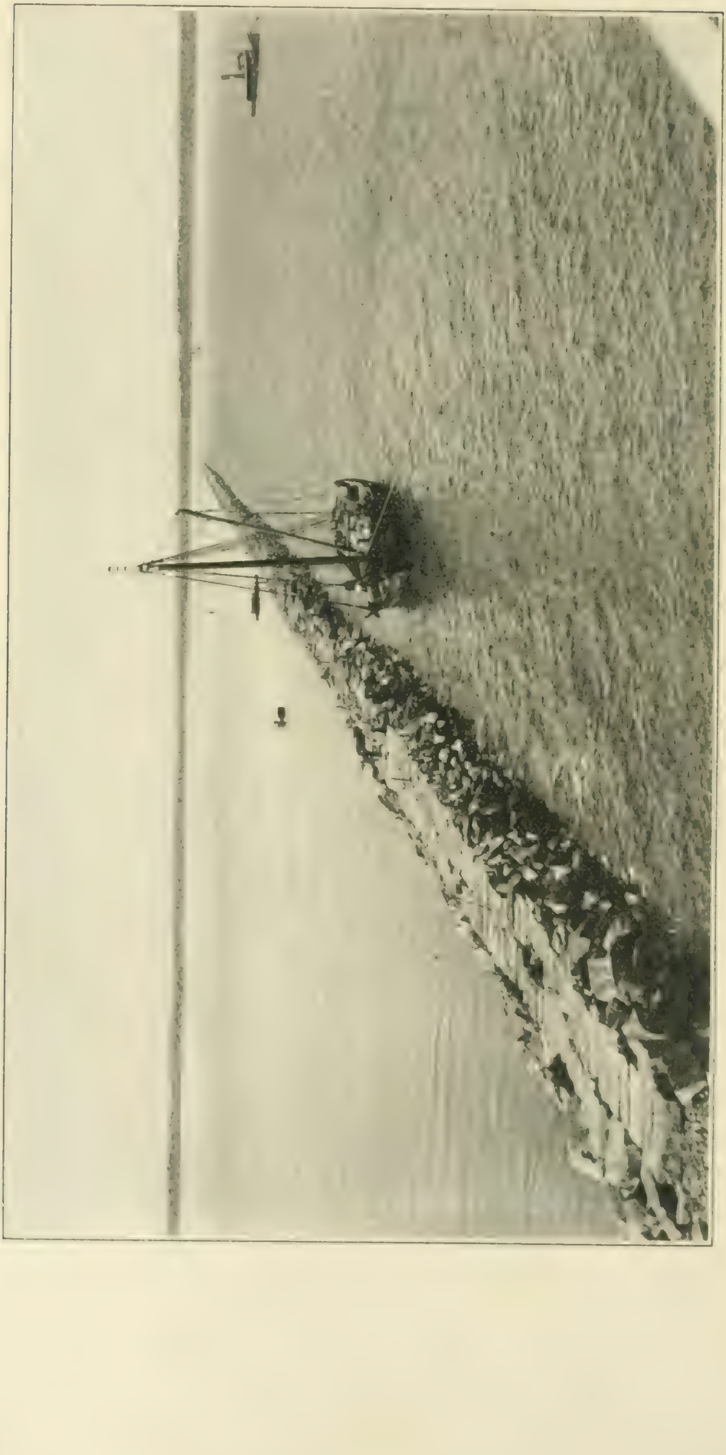
The present plan is to have a river and harbor bill each year. When the report on a survey is submitted the Engineers express an opinion as to whether it is desirable to make a single appropriation covering the entire work, or divide it up into several appropriations; and if the latter, how much should be appropriated each year. If Congress approves the project the recommendation of the Engineers as to the manner of making appropriations is usually followed. In the case of a large project, Congress frequently appropriates a sum to begin it, and authorizes the Secretary of War to enter into contract for the entire project, the remaining amount to be subsequently appropriated in the Sundry Civil Bill. This scheme works very satisfactorily, and results in lower prices, more effective work, and the project is completed and the full benefit received in a comparatively short time.

The Duck Island Harbor of Refuge is an example of the two methods. The original project for this harbor was adopted by the river and harbor act of September 19, 1890. Appropriations aggregating $120,202 were made from time to time, up to 1910. During these 20 years the breakwater westerly from Duck Island was built 2,697 feet long, but not to full cross section, involving the delivery and placing of 129,051 tons of riprap. In 1910 the project was revised, and an appropriation of $60,000 was made, followed by four more appropriations, each succeeding year, of $100,000, $50,000, $82,000, and $7,000, respectively. During the five years from 1910 to 1915, 257,303 tons of stone were delivered and placed, and the entire project was completed in 1915 for about $50,000 less than the original estimate.

Government river and harbor improvement in this district may be roughly divided into two classes, namely:

1. Deepening, widening and rectification by excavation, chiefly dredging; and
2. Protection by permanent works, such as breakwaters, jetties, dikes, revetments, etc.

Frequently both means must be used, notably in the case of rivers, and in some cases deepening, widening and rectification may be brought about by means of permanent works which so affect the currents as to produce the desired results. In many harbors it is not sufficient to simply deepen or widen the chan-



WEST BREAKWATER, NEW HAVEN HARBOR.

nels by dredging, for the action of storms and tidal currents would soon fill in the area dredged; and hence it becomes necessary to protect these areas from storms by breakwaters, or to so change the currents by dikes or jetties as to cause scour instead of fill. In river improvement especially both dredging and permanent works are likely to be needed, and this class of work calls for very careful study and consideration, as improperly designed works may often do more harm than good.

All, or nearly all, of the waterways now under improvement in this district were used for navigation to a greater or less extent in their natural condition, but in some cases, notably at Bridgeport, their depth and capacity have been so greatly increased that the original harbor is scarcely recognizable; and in one case, at Duck Island, a good harbor has been created where practically none existed originally. Bridgeport Harbor in its natural condition was very small and shoal; the available low water depth on the bar at its mouth was only five feet, and in the Pequonnock River, at the head of the harbor, there was from two to five feet. At present two breakwaters have been built extending the harbor over 3,000 feet farther to the southward and more than doubling its capacity; the entrance channel is 300 feet wide and twenty-two feet deep, an increase of seventeen feet from the original depth. The Pequonnock River channel is eighteen feet deep, large anchorage basins have been provided, and various branch channels have been dredged, some now providing a low-water depth of twelve feet where the bottom was originally bare at low tide.

In addition to the actual work of improvement by dredging, building breakwaters, etc., the Engineer Department is charged with the duty of seeing that the laws for the preservation of the waterways are observed. This involves the establishment of harbor lines; the issuance of permits for and supervision of private work, such as the building of bridges, bulkheads, wharves, etc.; the removal of obstructions to navigation, including wrecks; the prevention of injurious deposits, and various other related matters. Work of this character, together with the preliminary examinations and surveys ordered by Congress, which I have already mentioned, have taken much of the time in this district in recent years, as they require very careful consideration and often a large amount of field and office work.

After a project has been adopted by Congress, and an appropriation made, the District Officer must submit to the Chief of Engineers a scheme called a "subproject" for the expenditure of the money, and the method (contract work or hired labor) by which he proposes to do the work. In this subproject no change whatever can be made from the original project as adopted by Congress; that is, the work when completed must be exactly as authorized by Congress; the subproject dealing only with the methods by which, and the order in which, it is to be accomplished. After the subproject is approved, and not until then, the work may be begun. In this district, all dredging and most of the breakwater work is done by contract. The usual method is to prepare careful specifications and advertise the work in the professional journals for at least thirty days. The bids are opened in public and the District Officer recommends whether or not any be accepted, and if so, which. If he considers all of them too high, he recommends that they be all rejected, and the work readvertised. If not too high, the lowest bid is usually recommended for acceptance, but in rare cases the low bid may be rejected as informal, manifestly too low, because the bidder is known to be unable to satisfactorily perform the work, or for some such reason. I may remark, however, that there must be an extremely good reason to cause a District Officer to recommend the acceptance of any but the lowest bid. If the District Officer's recommendation is approved by the Chief of Engineers, contract is entered into and the work begun.

The specifications now in use are the result of long experience and follow a standard form with sufficient variation to cover each particular job.

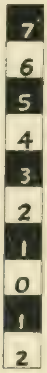
All work is done under the personal supervision of the assistant engineer, and is rigidly inspected by as many inspectors as may be necessary. These inspectors are required to be constantly on the work while in progress, and very commonly live on the contractor's plant, the contractor being paid by the United States for the accommodations and meals thus furnished; under no circumstances must there be any money transactions whatever between the inspector and the contractor. When a job is begun the inspector is furnished with a blueprint map showing the layout of the work, a copy of the specifications, a loose-leaf notebook, a tape, stationery, and frequently a transit. The contractor is required to furnish him with a carefully marked sounding rod or chain, and must also provide tide gauges, ranges, a boat and such assistance in the way of labor as may be required for sounding, setting ranges, etc.

Usually the first thing to do is to establish tide gauges. I need scarcely say that the tide rises and falls in all harbors and all portions of the rivers of this district which are now under improvement except in the upper portion of the Connecticut River, above Hartford. The mean tidal range in the harbors ranges from seven and one-half feet at the western end of the district to two and one-half feet at the eastern end; the maximum range is approximately twice the mean range. All dredging and breakwater work is referred to mean low water, at the place where the work is done, as zero; that is, the depth of dredging is so many feet below mean low water and the height of a breakwater is so many feet above it. It is customary on Engineer Department maps to omit the minus sign in front of all depths below the datum plane, and to prefix a plus sign to heights of points above mean low water. This is to avoid the constant repetition of the minus sign, by far the greater number of soundings, of course, being below the datum plane.

In each harbor and river under improvement there are permanent bench marks, established before the work is begun, their location being chosen, so far as practicable, so that a direct vertical measurement may be made with a rod or tape to the surface of the water at any stage of tide.

The tide gauges used in dredging and breakwater work (Fig. 1) are boards about a foot wide and fully as long as the maximum range of tide at the place where work is being done, say about fifteen feet for the western end of the district, and about six feet for the eastern end. These boards are usually divided into sections, each a foot long, painted alternately black and white, and numbered up and down each way from zero, which is placed two feet or more from the bottom of the board, to allow for unusually low tides. The figures are six inches high, white on the black sections, and vice versa. With the aid of the bench mark the inspector sets his gauge, usually nailed to a stake, pile or wharf, so that the bottom of the zero section is at mean low water. Generally several tide gauges are set at different points along the channel or breakwater, so that one will always be in plain sight from the point where work is in progress. Careful attention to the tide gauges is of the utmost importance, as upon them depends the depth that is made or the height of the structure that is to be built.

The next thing is to lay out the work and mark it, usually by ranges. For a breakwater or jetty a single line of ranges, marking the center of the structure, is generally used. These ranges are usually set from permanent transit stations on shore, and additional transit stations and bench marks are established on the structure as soon as a short section of it has been built, more points and benches being added at frequent intervals as the work progresses, so that its axis is determined by an accurate transit line, and its height by a line of levels.



SKETCH OF TIDE GAUGE

FIG 1

In the case of a dredging job, the area to be dredged is laid out, frequently with the aid of a transit, from the data given on the blueprint, and is divided into longitudinal sections, corresponding in widths to the cuts which the dredge can make. This varies greatly with different dredges, ranging from twenty feet for a small scoop, to 100 feet, or even more, in the case of a big pump or ladder machine. The inspector is usually aided in the laying out of the work by additional men from the office; sometimes it is done by a regular survey party in charge of a junior engineer. The cuts are generally marked by stakes or piles, on which are fixed flags or targets, so that they may be plainly visible. Sometimes objects on shore, such as church steeples, prominent trees, the corner of a house, etc., may be utilized, and frequently the precise location of the channel is chosen so that it will follow some natural range which will aid in navigating it after its completion.

Too much care can scarcely be taken to carefully lay out the work so that the channel as actually dredged will follow the lay out on the map, and so that the cuts will be parallel and of the same width throughout, so as to leave no ridges between them.

Beyond this point the duties of an inspector on dredging and breakwater jobs differ considerably, and we will consider them separately, taking the dredging first. After laying out the work, he must provide for measuring the material. If it is to be removed in scows, the scows must be carefully measured while empty and a table made showing the capacity of each when even full, and when slack by various small amounts, as six inches, one foot, one and one-half feet, etc. This is often quite a job of itself, and requires much care, as a very slight difference in some of the measurements of a large scow, such as the length, width, etc., may produce quite a large error in the total capacity. The scows should always be reasonably clean, and the doors tightly wound up when they are measured, and it is frequently necessary in the case of large scows that they be beached, so that reliable measurements may be taken of the bottom, which is under water when the scow is afloat.

If the material is to be handled by the hydraulic (suction) method, it is generally measured by carefully cross sectioning the bottom before and after dredging. This requires much care, and must be done by a party of several men. Various methods are followed. In the case of a comparatively narrow channel with shallow water or banks along the sides, so that stakes may be set to hold it, a carefully marked wire or wire cord may be stretched across at regular intervals, of twenty-five, fifty or 100 feet, depending upon the uniformity of the bottom, and soundings taken from a boat at the marks on the wire. When the depth or other conditions are such that a wire cannot be conveniently used, the soundings may be taken from a float, so anchored that its location and movements may be easily controlled.

In any case, the soundings before and after dredging must be taken with such accuracy as regards depth and location as to correctly give the amount of material removed.

Measurement of material after being placed ashore is not usually satisfactory as showing the amount removed from the channel, for a considerable quantity is carried away in suspension, hence this method is not used in this district.

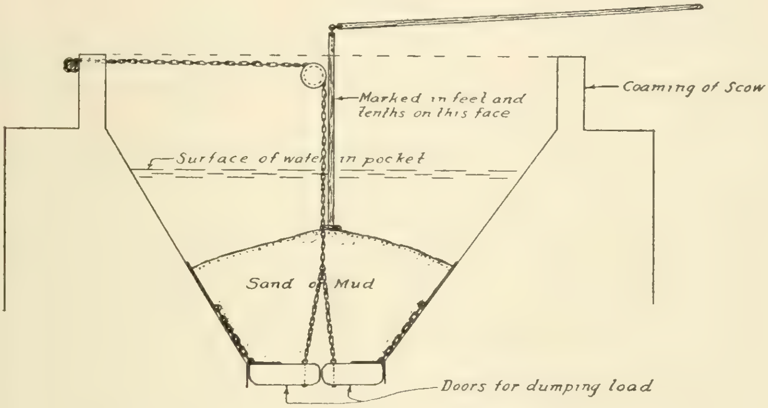
Having established the tide gauges, laid out the work, and provided for measuring the material, the work and the inspector's troubles (for he has many of his own) are ready to begin. His most important duties are to see that the dredge is kept on line so that the cuts follow the ranges; to see that the specified depth is made, and to carefully measure the dredged material. He must also record the distance moved by the dredge each day on each cut, and plat it on his progress sheet; note the time when the loading of each scow is begun and finished; note all delays of fifteen minutes or more, with the cause; and record the character of the material dredged, and the depth before and after dredging. At the close of the 10th, 20th and last day of the month he must submit a report giving all the data named above. He must also, as soon as practicable after the job is begun, make up and send in a description of the contractor's plant and force, and keep this up to date by additional reports each ten days.

It is a common idea, sometimes shared by new inspectors themselves, that the job of a dredging inspector is a good deal of a cinch. But in reality there is plenty to keep him very busy.

Keeping the dredge on line means that he must be on deck nearly every time the dredge moves ahead, to see that she is properly lined up. Often he gives the signals himself.

Watching the bottom to see that the required depth is made takes a large part of his time, for he must sound across the stern of the dredge and along her sides very frequently, at every move if the material is hard. In fact the extent to which he uses his sounding rod or chain is a very fair indication of how well he is attending to his job. In addition, he must frequently get out in his skiff and sound ahead to keep track of the cutting bank; and behind, to be sure he has missed no lumps or ridges that may have been left. If any are found, the dredge must be moved back to pick them up. This causes loss of time for the dredge, and hence is often objected to by the contractor or his representative, and it frequently requires some little persuasion on the part of the inspector to get it done.

The measuring of the loads of the scows does not take very much time, but it must be done very carefully. And it is here that there is frequently a difference of opinion. When the scow is even full, there is little chance for argument; but if it is slack, as very often happens in the case of heavy material like sand and gravel, it is not so easy. In such cases the load is usually uneven, often partly or entirely covered with water. It is then necessary to carefully sound each pocket to determine how much—six inches, one foot, three feet, or whatever it may be—the load will level off below the top of the coamings. The inspector uses a rod marked in feet and tenths, and if the scows are large it is necessary to have such a rod fastened to another one by a hinge so as to be able to take soundings in the center of the pocket (Fig. 2). Having determined how much each pocket is slack, the actual load is easily obtained from the table.


Coaming of Scow
Marked in feet and tenths on this face
Surface of water in pocket
Sand or Mud
Doors for dumping load

SKETCH OF SCOW-MEASURING DEVICE

FIG. 2

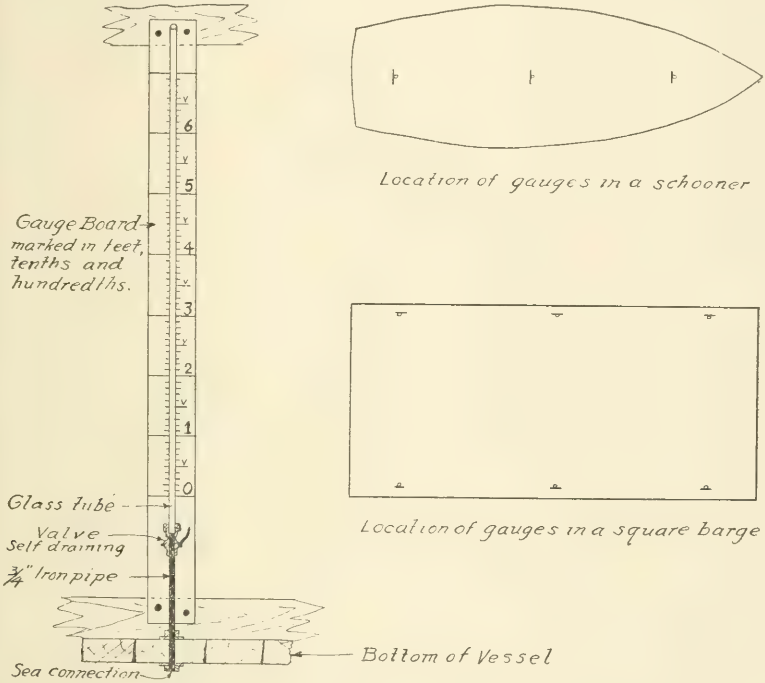
The distance dredged is kept in various ways, such as by noting the distance the dredge moves past objects forming ranges, known as "cross ranges," nearly at right angles to the cut; by sextant angles from the dredge; transit or sextant angles from the shore; by a marked line arranged to pay out astern as the dredge moves ahead, etc.

All of these duties call for careful attention, and no small amount of tact. A good dredging inspector who will succeed in getting a good job, and at the same time not be constantly in a row with the contractor and his employees, is a scarce article and earns every cent of his salary.

After the dredging is reported completed, a careful examination of the bottom is made by a regular survey party, and if it is found that material has been removed from below the regular depth plus the allowable overdepth or leeway (usually one to two feet) or from outside the prescribed limits, the amount of material thus removed is deducted from the final estimate. If any shoals, lumps or ridges are found, the contractor is required to remove them before final acceptance of the work.

The inspection of stone work, such as breakwaters, dikes, etc., is quite different from dredging work. Practically all structures of this class in this district are now built of riprap, which is paid for by the long ton, 2,240 pounds, delivered and placed in the work. To measure it the vessels in which it is delivered are first carefully weighed in. These vessels are provided with from three to six gauge glasses—glass tubes similar to the gauge glasses of a boiler—with an outboard connection at the bottom, and provided with a scale (wood or metal) carefully marked in feet, tenths and hundredths (Fig. 3). Before weighing in, the inspector carefully ties in these scales so that their position cannot be changed without his knowledge. The vessel must be pumped dry, and have on board only her regular fittings and equipment. The stone comprising the load is then accurately weighed on verified scales and readings are taken on each gauge at frequent intervals as the loading proceeds, care being taken to trim the vessel as evenly as practicable at each reading. Often two or more loads of each vessel are thus weighed in. From the results of this weighing, tables are constructed to give the load for each hundredth of a foot. Thereafter, when a vessel arrives at the work, the inspector reads the gauges before unloading begins and again when it is finished, and thus with the aid of his tables determines the amount of the load.

Although to look at a breakwater one might think it was simply a pile of stone, in reality much skill and care must be used in building it. If the water is deep it is often permitted that below a certain depth, say ten or twelve feet below mean low water, quarry run may be used, and this is sometimes dumped from bottom-dumping scows, several hundred tons at a time. The upper portion of the structure, or in shoal water, the whole of it, is built with stones delivered and placed by derricks, one at a time, and this is the work that requires skill and careful attention on the part of the inspector and the contractor's employees.



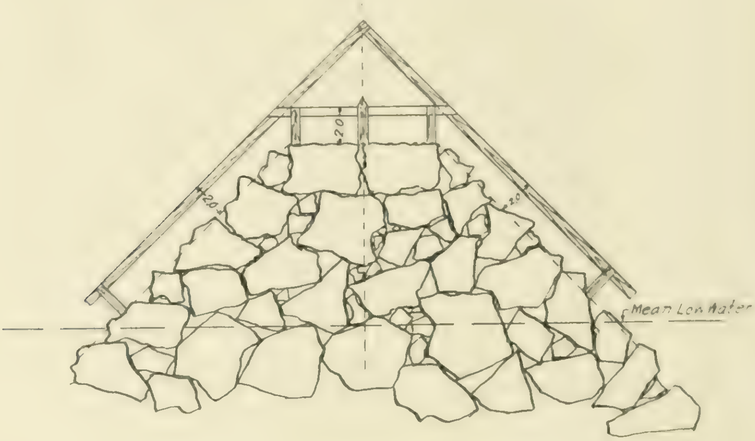
Location of gauges in a schooner

Location of gauges in a square barge

SKETCH OF GAUGES IN STONE SCOW

FIG. 3

The height of the breakwater, the width of the top, and the slope of the sides above water are commonly obtained by means of screeds which are set by transit and level so as to be a certain fixed distance, generally one or two feet outside of the neat line of the breakwater (Fig. 4). By measuring from the line of these screeds, an inspector can readily determine whether any stone is slack or full.



SKETCH OF BREAKWATER SCREED

FIG. 4

What I have said may perhaps give you a rough idea of the general way in which river and harbor work is carried on in this district. Of course, there are many details that I have not gone into at all, and have only barely referred to some of the different kinds of work that are really of much importance, but with the limited time at my disposal I am unable to cover it all.

Before closing, the following historical data may be of interest: The first appropriation by the United States for any river and harbor work was $30,000 in 1802, to be expended in repairing and erecting public piers in the Delaware River. The first appropriation for this district was $150 in 1821, for the removal of obstructions placed in the Thames River by the commander of American ships during the war of 1812 with Great Britain.

The next appropriation was $1,500, in 1827, for Saugatuck River and Harbor. During the next few years, up to 1830, appropriations had been made for Stonington Harbor, Southport Harbor, and for surveys at Norwalk and Stamford harbors, but no other work was done in the two latter-named harbors for over fifty years.

The total appropriations for this district have amounted to $7,177,623.81; and for the entire United States, from the beginning in 1802, to date, a trifle over $850,550,000 has been appropriated for river and harbor improvement. The largest amount appropriated for any one project in this district is $1,264,000, for the breakwaters at New Haven; and the next largest amount is $1,012,773.90, for improvement of New Haven Harbor. At present there are 8 miles of channels and 133 acres of anchorage basins under improvement in New Haven Harbor; and during the past 16 years over 7,000,000 cubic yards of material have been removed from this harbor, at an average cost of 14 cents per yard, including administration and inspection. Were this material to be piled up on the New Haven Green in the form of a rectangular block, it would make a pile covering the entire green to a depth of 270 feet.

To indicate the rate of progress on a dredging job, I may say that during the last contract work in New Haven Harbor, by the Morris & Cumings Dredging Co., 806,118 cubic yards of material, mainly mud, were removed in 1408 hours and 10 minutes of actual dredging time for one dredge, or an average of 572 cubic yards per hour. Two dredges were employed part of the time, but the time named is that of the two dredges added together. The maximum day's work was 18,156 cubic yards in 17 hours and 55 minutes actual work. The time lost on the job was slightly more than 40 per cent of the total time available for work.

APPENDIX.

Description of Dredging Plant.

The dredges employed may be divided into four groups or classes; clam shells; scoop dredges; ladder dredges; and the hydraulic or pump dredges. Each of these general groups has various types, and each has its own advantages and disadvantages.

The clamshell takes its name from the bucket used, which is roughly like the two shells of a clam, although orange peel buckets, which have a resemblance to the quartered skin of an orange, are often used on this style of dredge. In dredges of this group the bucket, whether clam shell or orange peel, is handled from the end of a boom by means of two chains or wire ropes, one of which closes and raises the bucket, and swings the boom toward the scow; and the other opens the bucket and swings the boom away from the scow. The chains or wires lead from the buckets through two sheaves, one on each end of the boom at its outboard end, thence through two leading sheaves on each side of the dredge well above the deck, and thence to two drums operated by the main engines. These drums are usually controlled by frictions, which, in turn, are operated by the runner by means of levers. Owing to the divergence of the wires as they pass from the outboard sheaves to the leading sheaves, the boom is swung at the same time that the bucket is raised or lowered.

This type of dredge has several advantages: (1) Its first cost, operating expenses and repair bills are all comparatively small; (2) owing to its simplicity it is comparatively easy to get men to run it, as the only job aboard requiring much skill is that of runner, who is ordinarily captain, and almost any fairly intelligent man can soon learn the job; (3) the depth to which it can dredge is much greater than that of any other type, as it is limited only by the length of the wires or chains, and the capacity of the drums, which is for many kinds of work a great advantage. This type is the only one which is suitable for digging deep holes, as for foundations, etc.; (4) it can work in water only deep enough to float the hull, so that if the dredge itself is of light draft, it can work in very shallow water; (5) it can very easily and at comparatively little expense be moved from one locality to another, and by unshipping the boom, which is very easily done, it is fairly seaworthy; (6) in soft dredging, mud or loose sand, particularly the former, it is very efficient.

The great disadvantage of this kind of dredge is that it is not efficient for hard material, such as compact sand or gravel or clay. This is because the bucket depends very largely upon its weight for its cutting ability, and the tendency is for the bucket, when it closes, to raise itself instead of cutting into the bottom, and this tendency is, of course, increased by the pull of the hoisting wires. Various types of buckets are used with more or less success to overcome this tendency, but the fact remains that the clam shell cannot dig as hard material as some of the other types, and the greatest efficiency of this type is in soft material.

The scoop or dipper dredges also take their name from the form of bucket, which is like a large scoop or dipper firmly fastened on the end of a long handle, which is hung, by means of trunnions, near the middle of an inclined boom, the foot of which rests on a turntable at the forward end of the dredge. The bucket is raised and lowered by means of a chain or wire rope, while another chain, attached to the handle, pulls it back under the dredge for another bucketful. The turntable is usually swung by means of an independent set of engines, operating a sprocket which engages an endless chain. The depth of the dredging is usually controlled by a steam pinch and friction on the dipper handle, although formerly a rack and pinion were used. A scoop dredge is practically a steam shovel afloat, so I need give no detailed description of this type, which is well known to you all. The principal advantage of this kind of dredge is its ability to dig hard material. This advantage is due to its general design which enables the power of the main engines to be used to pull the bucket through the material of the bottom. Dredges of this type can dig harder material than any of the others, although the ladder dredges come very close to it. It is to be understood, of course, that this applies to the general type, and not to individual dredges, for you might have a particular clam shell machine which could dig harder material than a particular scoop. The first cost, operating expenses, and repair of the scoop are more than for the clam shell, but not as much as for the ladder and pump dredges. A good scoop runner is usually harder to find than a clam shell runner; and in addition there must be a dipper tender upon whose skill greatly depends the character and success of the work. The depth to which the scoop dredge can work, of course, depends upon the length of the dipper handle, and this places a very decided limit on the depth this class of dredge can make, which is rarely over thirty feet. It is also necessary with most scoops to pull the bucket back partly under the dredge to get a good bite into the bottom, and this means that there must be more than enough water to float the dredge; so that it is rare that the scoop can work in less than six feet of water, generally more is required. It is as easily moved from one locality to another as a clam shell, but it is more difficult to unship the boom and dipper handle.

Sometimes dredges are built so that they can be used either as clam shells or scoop dredges, by changing booms and buckets. But dredges of this type are not, as a rule, very successful, and are apt to be like most half-breeds, and to have most of the defects and few of the virtues of either regular type.

Ladder dredges take their name from the resemblance of their buckets to a ladder. They have a number of comparatively small, scoop-shaped buckets fastened together like an endless chain. This chain of buckets is operated by the main engine, so that each bucket, one after another, scrapes along the bottom, and then, as it turns over at the top of its path, is discharged into a chute leading into a scow or ashore. This type of dredge is expensive to build, and its operating expenses, owing to the heavy repair bills, are often very large. The delays due to breakdowns are also likely to seriously affect its efficiency. The range of depth that it can make is also, like the scoop dredge, limited, and it cannot work up in narrow slips or corners like the first two types. Ladder dredges are usually large, and are not so easily moved as the clam shells or scoops. On the other hand, on large jobs, with plenty of room, they are frequently very efficient. They are largely used abroad, and have been employed on the Panama Canal, but only in a few cases in this district.

The three types described ordinarily dispose of the material excavated by placing it in scows in which it is towed to deep water and dumped. The fourth type, the pump or hydraulic dredges, in this district usually places the material ashore behind bulkheads. The large, self-propelled sea-going dredges which take the material directly aboard, in large hoppers, and then go to sea and dispose of it, have never been used in this district, although they have been very efficient elsewhere, as, for instance, at the entrance to New York Harbor. The pump dredges used in this district suck up the material from the bottom by means of a centrifugal pump and discharge it through a pipe, sometimes a mile or more in length. Attempts have been made to pump directly into scows, but not with any great success, mainly owing to the material remaining so long in suspension. Usually the outer end of the suction pipe is fitted with a mechanical agitator to stir up the material, so that it may be readily sucked up.

It is hard to compare pumps with other types, as they perform two operations, dredging and filling, at the same time, and ordinarily both are of value. It is very rarely that a pump can successfully compete with the other types if the filling is of no value, especially if, to the actual cost of dredging, be added the cost of building the bulkheads and levees to retain the fill, and the laying and maintaining of the pipe line. The first cost of the dredge is large, and the cost of getting the plant, including the pipe line, on the job and ready for work is much greater than in the case of other types, so that pumps are not suitable for small jobs. For large jobs, in protected locations, where the fill is valuable and the material is suitable for pumping, they are very efficient.

THE PROPOSED THAMES RIVER RAILROAD BRIDGE AT NEW LONDON, CONNECTICUT.

By P. B. Spencer, Div. Eng'r., N. Y., N. H. & H. R. R., Mem. Conn. Soc. C. E.

This paper is not to be technical in character. It is presented at this time, at the request of our president, that the members of the Society may be in possession of general information regarding a project, which, though not yet under actual construction, has aroused more or less interest in engineering and contracting circles hereabout.

The projected bridge is hardly beyond the preliminary stage at present; however, the management of the New Haven Railroad expects that the coming season will see the construction stage begun.

The fact that a new railroad bridge across the Thames River, to replace the existing bridge, is under consideration, is a forcible example of the rapid progress in railroad development during the last quarter century. The present bridge was opened to double track traffic on October 10, 1889; it was designed by the late A. P. Boller, consulting engineer, the design having been passed upon by an independent committee of engineers, one member of which was Octave Chanute, later president of the American Society of Civil Engineers, also by a joint Army and Navy Board of Engineers. Doubtless the structure was expected by the designer and his consulting associates to serve all requirements for a great many more years than has been the case. In fact so rapid was the increase in train loads that it became necessary in 1908 to reduce the loading on the present bridge by adopting the gauntlet method of operation across the structure. This naturally reduced immensely the efficiency of the bridge for the handling of traffic, introducing train delay conditions which have become steadily worse as volume of traffic has increased. It may be noted that the present bridge was designed for a loading a little less than Cooper's E-30. The New Haven Road management has thus been confronted for the past eight years with the knowledge that a large expenditure would soon be required for the construction of a new bridge across the Thames River, and the authority to proceed with the preliminary work was given about two years ago, while authority for the construction work has now been given.

In planning for the new bridge these points were considered: (1) Location of bridge; (2) location of piers; (3) design of substructure; (4) design of superstructure.

Location of Bridge.

The proper location for the new bridge is manifestly upstream from the present bridge, to avoid the necessity of sharpening the curvature of the main line track approaches. Considerable thought was given to the possibility of interference with the pile supported piers of the old bridge during the construction of the piers for the new bridge, and it was determined to locate the new bridge tangent 185′ upstream from the centerline of the present bridge, thus giving something over one hundred feet clear between the nearest points of the new and old piers.

Location of Piers.

The most interesting feature of the work to date has been the development of the economical pier location. This was done by means of a thorough examination of subsurface conditions along and adjacent to the new bridge tangent. This examination furnished information of great value in determining the location for the new piers, notwithstanding the fact that the location of the channel piers is fixed between rather narrow limits by the proximity of the present bridge, which is to remain and be converted into a highway bridge after its abandonment for railway traffic. Of four tentative schemes for span arrangement and pier location the scheme adopted after, and as the result of, the test borings is estimated to cost nearly a half million dollars less than the scheme which figured highest and which was much favored previous to the test borings.

These test borings were made during 1913 and 1914 by means of wash boring methods for the soft material and the use of

Dobbin's shot drills for removing sample cores from the rock. At the start, one machine was mounted on the side of a lighter. The lighter being about the width of the base of the proposed piers, a second machine was soon added on the other side of the lighter, thus allowing two borings to proceed at once, and materially decreasing the cost per foot of the work. Later a second lighter equipped with two drills was added to the equipment. With this plant a maximum amount of hole per month was obtained during January, 1914, of 1,087 lineal feet, of which 1,013 feet was in overlying material and 74 feet in rock. In prosecuting the work an 8″ casing was first sunk as far as possible; sometimes this reached the rock surface,—if not, a 6″ casing was inserted and the hole continued. On a few holes, where the overlying gravel was of greatest depth, further reduction in diameter of casing pipe was necessary in order to reach the rock surface, although it was always best to get to the rock surface with as large casing pipe as possible, as it was found that better speed and better cores were obtained in the rock drilling with large core bits.

In the course of the investigation, seventy-five test holes were put down, totalling 7,296 feet, of which 6,627 feet were through overlying mud, clay and gravel, and 669 feet into rock. The highest elevation at which rock was found within the limits of the bridge is at 48 feet below M. L. W.; the lowest elevation for top of rock is at 194 feet below M. L. W. The greatest depth of any hole was 199.5 feet below M. L. W.

The general result of the soundings showed rock at great depths from the center of the stream toward the west. This rock is, however, overlaid by a bed of gravel and sand varying from fifty feet in depth at the center of the stream to one hundred feet in depth at the western shore. Toward the east from the center of the stream the rock surface rises quite rapidly, while the overlying stratum of gravel and sand practically disappears at a point midway between the center of the stream and the eastern shore but reappears again as the shore is approached. The water varies in depth between eight and ten feet at the proposed abutments and forty-five to fifty feet at the channel. Unstable material, such as mud, silt, and clay, varies in depth between ten to twenty feet at the abutments and eighty feet at the channel.

DESIGN OF SUBSTRUCTURE.

It was desired to avoid the use of piles on account of the great depth of unstable material in the river bed. The result of the test borings indicated that a bed of gravel, suitable in depth and character for foundation, exists from the center of the stream toward the west, and also at the eastern shore, while between the channel and the eastern shore the rock rises to within the pneumatic limit, furnishing a suitable foundation for a pier of this type. Accordingly, the distance east of the channel will be divided into two spans, the center pier of which will be founded upon rock by the pneumatic process. The entire bridge will consist of five spans with approximate lengths from west to east, as follows: 185′, 330′, 212′, 330′, 330′, the total length being 1,387′. The 212′ span is across the channel and will contain the single leaf lift span; the piers at the end of this span are the largest and deepest of the bridge, the trunnion pier being somewhat larger than the other. These two piers are to be sunk by the open-well dredging process. The larger will be about forty-two feet wide by about ninety-nine feet long, in foundation plan. It is expected that the two channel piers will be sunk to a depth of approximately 142 feet below M. L. W., and will rise about twenty-six feet above M. L. W. Eight dredging wells will be provided in each pier, arranged in two rows of four each, thus facilitating control during the sinking process. The space between the caisson shell and the dredging well walls will be filled with concrete deposited in the dry as sinking progresses. When the proper foundation material is reached, the dredging wells will be filled with concrete, deposited under water. The pier shaft above water will be smaller in size than the caisson dimensions. The bridge seat of the larger pier will be approximately thirteen feet by eighty-eight feet. The shaft will be of concrete, surrounded at water level by a granite masonry facing from four feet below to eight feet above M. L. W.

The westerly pier, between the 185′ and the 330′ spans, will not be so deep as the channel piers. This pier will probably be constructed by the open-well dredging method, but may possibly be built by the pneumatic method. It will be founded at a depth of 100′ to 110′.

The open-well dredging method furnishes a means whereby piers of important structures may be sunk to depths below the pneumatic limit, the result being a solid foundation. The method has been little used in this section of the country, but there are some notable examples of its use on the Pacific coast and abroad. The Hawkesbury bridge in New South Wales, Australia, built in 1886 to 1889, had six piers sunk by this method to depths varying from 98′ to 160′ below low water. The Willamette River bridge, at Portland, Oregon, built about 1911, has two piers by this method, one reaching a depth of about 132′ below low water.

SUPERSTRUCTURE.

As indicated in a previous paragraph, the superstructure will consist of five spans of approximate lengths 185′, 330′, 212′, 330′, 330′, total, 1,387′. The final superstructures will be two double track bridges, the substructure being built for four tracks. One of the double track superstructures will be constructed now, the other added when required.

The structure will be designed for the heaviest loading now in use or contemplated upon any Eastern road, with ample allowance for impact. The lift span is to be of the Strauss type and will be about 188′ long, symmetrical in the 212′ span, the trunnion and rest ends supported by 12′ cantilevers from the adjacent 330′ spans. The navigation channel through the new bridge will be in line with the westerly channel through the present bridge.

DISCUSSION.

MR. TERRY: The piers, as I understand you, do not go down to rock?

MR. SPENCER: No, except with Pier 4. We get down to a good gravel foundation with the other piers. There will be perhaps twenty-five to thirty feet between the bottom of the caissons and the rock level.

MR. TERRY: What is your unit load per square foot?

MR. SPENCER: Normal load is estimated to be about five to six tons per square foot at the base of the pier.

MR. TERRY: That comes from the reduction in the size of the foundation above the base. Otherwise you would have gotten more than that?

Mr. Spencer: Yes.

Mr. Charles Rufus Harte: A word about the old bridge may be interesting. It was designed and the construction was supervised by Mr. A. P. Boller. Mr. Edwin P. Dawley, then Chief Engineer of the Boston and Providence R. R., objected to the design of the superstructure on the ground that engine and train weights would increase much more rapidly than had been figured and he expressed the belief that in twenty years—this was in 1888—the structure would be inadequate for the service, and urged a much stronger design. His suggestion was not adopted, however, but in less than ten years his judgment was vindicated.

The bridge was opened in October of 1889, at which time its swing span of 502½ feet was the longest double track draw in the world and I think there are to-day but few longer.

Mr. Bennett: As a matter of interest the State Highway Department has got to transfer the old bridge into its keeping. If any one has any information as to whether it is safe or not I would be very glad to get it. Possibly Mr. Harte may have some information or may be able to tell me where I could get it.

Mr. Harte: I think there can be little question as to the present strength of the bridge for highway purposes; the railroad loads for which it was destined were much heavier than any reasonable highway duty, and the present trouble arises not from any weakness in the structure as built, but because economic conditions of later years made necessary far heavier loads than were anticipated.

There was a little trouble at first with the substructure, but this was soon remedied. The center pier rests on a heavy timber grillage in turn resting on a crib. To bring these two into perfect bearing the completed center pier was loaded with 2,700 tons of pig iron which was twice the weight of the draw span. This remained for some time, and as at that time iron was high there was a good deal of wonder and comment by the newspapers. The west pier was designed with a series of footings to rest on some 120 piles. The latter were all driven, but for some reason—perhaps lack of reason is better—these footings were kept flush with the pier proper instead of stepping out, with the result that practically one-half of the piles were outside the masonry, while those under the pier had double the intended load and promptly began to yield. It was at first thought that this was an adjustment of loads that would soon be over, but as the pier continued to settle it was realized that the trouble was more serious. An investigation by Mr. Dawley developed the real facts, and as the unloaded piles were in perfect condition he drove a few new ones for good measure, built the omitted footings, bonding them well into the old work, and the settlement was at an end without stopping a single train, although at times they were slowed down. The total settlement was sixteen and one-half inches on the north end, and ten inches on the south end.

As to records of the bridge, Mr. Boller made to the Boston and Providence Railroad a report on the construction, but as I remember it, this is a popular rather than technical report. The *Engineering Record* of 1888 and 1889 had several articles on the bridge, and the treatment of the west pier—which was an admirable handling of a very difficult problem, although as I have described it, it may sound as if simple and easy—was there reported in 1893. Undoubtedly the other technical papers of those years have articles, although I do not know how detailed, for the bridge and the pier treatment were both recognized at the time as very notable.

DESIGN OF THE NEW STRATFORD AVENUE BRIDGE, BRIDGEPORT, CONN.

By W. Watters Pagon, Principal Assistant, Greiner & Whitman, Consulting Engineers.

In common with most of the cities along the Connecticut shore highway, Bridgeport is building a fine new bridge, located on the line of Stratford Avenue. This highway carries heavy local and through traffic between New York, Providence and Boston, and it is becoming evident to the cities along it, that imposing bridges appeal to the automobilist and spread the cities' renown to other states.

The Stratford Avenue Bridge in Bridgeport not only serves as a gateway for highway traffic entering the city from the east, but it also acts as a gate at the entrance to the harbor, being located so that most boats pass through its draw, hence the architectural design of the bridge has been drawn so as to make the structure in harmony with these two ideas. The width of the bridge was fixed at 80 feet so as to provide adequately for all present and future traffic and the approaches are flanked with massive but graceful concrete pylons marking the ends. The channel is flanked by imposing towers containing the operating apparatus for the draw span and comfort stations for men and women.

The Stratford Avenue Bridge Commission, of which Lieut. Governor Clifford B. Wilson is chairman, investigated numerous locations for the new bridge in order to determine which would give the most satisfactory approaches. After investigating six or more designs, it was finally decided to build on the location of the present bridge with additional width gained by extending the bridge to the northward. Owing to the difficulty and the expense of securing the right of way for a temporary bridge and because of the serious interference with vehicular and street car traffic that would be caused, it was decided to build the north half of the new bridge without interfering with the operation of the present structure and then after the completion of this half

STRATFORD AVENUE BRIDGE.

to throw traffic on to it while the old bridge was being removed, and the south half built. As a result it became necessary in reality to build two bridges 40 feet wide, side by side, connecting them together after completion, the channel as relocated by the War Department's engineers permitting this construction because of the possibility of swinging the old draw between the new bascule leaves when in the open position. All of the smaller piers have been designed in two distinct halves, but in the case of the abutments and channel piers, where this could not readily be done, the south half will be built as a continuation of the north half. The bascule span will be built as four independent leaves, each equipped with its motor and machinery, which after completion will be connected together so that the two halves of each leaf will act as a single leaf.

The foundation conditions in the Pequonnock River at Bridgeport are such that there have been several instances of settlement in other bridges constructed there, hence careful borings were made and test piles driven to determine just what character of materials would be encountered. Commencing at the west, or Bridgeport end, the rock is found relatively close to the surface overlaid by sand, then proceeding towards the east, the rock falls off quite rapidly and the sand and gravel is overlaid by a thick bed of mud. At the east end the rock is found about 100 feet below the surface and is overlaid by sand and gravel, mud and a fill made up of various kinds of refuse. The test piles driven show that the sand and gravel are not of the nature of hard pan but would permit considerable penetration of the piles, and subsequent driving seems to indicate that this material does not consolidate very materially under the driving of the piles.

Because of the character of the loads that are carried by the channel piers, it was decided to carry these down to rock by the use of pneumatic caissons and the type finally adopted contemplates rectangular hollow piers floored over some feet below low tide to form a pit for the operation of the draw span. Other spans are supported on piles driven to rock or to good refusal. All foundations are faced with granite to prevent injury to the concrete by the action of sea water which in Connecticut is likely to be quite severe.

The height from top of roadway to high tide is small because of the presence of the overhead structure of the New York, New

Haven and Hartford Railroad at the west end, making it impossible to elevate the west approach. This limited clearance, therefore, prevented the adoption of an arched type of bridge, hence it became necessary to adopt the beam or lintel type, and the architectural features have been carried out consistently following this idea. Great care has been exercised to get the best possible details in the fascia, and the brackets and other portions of it will be faced with 1:2 mortar, to permit of accurate workmanship.

The hand rails are of cast stone carefully made in the factory and then set up in place, the intent being to secure the most perfect hand rail that can be obtained at reasonable cost because of the fact that this feature of the bridge is the one that is seen by the greatest number of persons and should therefore be of the highest order.

The operator's and comfort houses have been designed to carry out the architectural idea that they constitute a gateway to the harbor. They will be of two stories with a basement, the upper story being used for storage purposes. The ornamental trim of the houses will be of cast stone to conform with the hand rails and each house will be surmounted by the seal of the City of Bridgeport.

The draw span will be of the deck trunnion bascule type built under the Strauss patents and will have 135 feet channel at right angles with the bridge or feet at right angles to the line of the dredged channel.

The construction of the bascule piers, as was noted before, contemplates the sinking of a hollow rectangular working chamber surmounted by walls enclosing a space which will be floored over so as to form a pit in which the bascule leaves of the bridge will operate. At the center of the pier there will be a temporary cross wall so as to make a complete half pit, and after the completion of the bridge a doorway will be cut through this to provide for communication. The operator's and comfort houses will be supported on cantilever beams projecting from the ends of the pit, and in the space below these houses will be rooms for heating apparatus and the storage of coal so that the entire first floor will be free.

The comfort stations will be equipped with modern plumbing and well appointed fittings and will be floored with tile. On the bridge and approaches there will be white way lamps similar to those in use throughout Bridgeport, and the trolley wires will be carried on center pole construction so as to eliminate the unsightly overhead work as far as possible, and also to avoid difficulties during construction.

It is hoped that the New Haven Railroad can be persuaded to alter their structure where it crosses the west approach of the bridge and either erect an ornamental concrete structure or else encase the present structure in concrete so as to improve the conditions at this point.

Referring to the perspective view, it can be seen just how the bridge conforms to the site and furnishes a gateway to the upper harbor and to the City of Bridgeport to persons coming from Stratford, New Haven, and the east. It has been frequently found that the erection of a handsome structure in a prominent location, as is the case here, results in a substantial improvement in the architecture and general condition of the surrounding development and the City Planning Commission of Bridgeport have had plans drawn showing what can be done towards assisting such development and fitting it in logically with the existing means of communication. With such development carried out, Bridgeport would be able to boast of as attractive an entrance as any of the American cities and would approach some of the European ports in this respect.

The Connecticut Company, which operates over the trolley tracks on the bridge, in carrying out a very broad policy which they have adopted, voluntarily contributed the sum of $70,000 or about 15 per cent of the total cost of the bridge, and in addition will handle at their own expense all changes in tracks and wiring, which may amount to as much more.

DISCUSSION.

A MEMBER: I would like to ask Mr. Pagon how he proposes to carry those tracks, what form of construction?

MR. PAGON: On the bascule span. It is proposed to carry each rail on a timber nailing strip bolted to the steel stringer. The nailing strip will come between the rail and the steel stringer as a sort of cushion. On the concrete spans steel ties and ballast will be used.

Mr. Bennett: What is the pile loading on the Stratford side?

Mr. Pagon: I believe there will be only about sixteen tons each on those piles. We found after the pile point was down about sixty feet below the surface that the sand and gravel were solid but uncompacted.

Mr. Bennett: How do you propose to waterproof the counterweight pits?

Mr. Pagon: We plan not to use any waterproofing compound, but to use such a dense mixture of concrete that the pits will stay dry. We have used both waterproofing and dense concrete, and find that we can get a perfectly dry pit by just using dense concrete.

Mr. Bennett: How dense?

Mr. Pagon: One of the features is to use a wet mixture. Then if the 1:2:4 mixture does not produce a perfectly dense concrete we will alter the proportion so as to get a dense concrete, and will test until we get it. However, we have very little trouble in getting results with the straight 1:2:4 mixture.

A Member: Is it possible to put in some large manholes there to help in the disposal of snow?

Mr. Pagon: We have considered that feature in one other bridge; and we could adopt it here if it was necessary. There is no reason why in any one of the fixed spans we could not have a manhole in the roadway. The chances are that the Government's engineers would have an objection, however, because they do not like to have street refuse dumped into any harbor. The only real objection, therefore, to such a scheme, is the Government's objection to the method of disposal.

Mr. Harte: I think there is a penalty under a Federal Statute for dumping snow or anything else into a harbor.

A Member: This is to be caisson construction?

Mr. Pagon: Only for the two bascule piers. The idea for the other piers is to build first a cofferdam and finish the first or north half of the pier; then remove that cofferdam and build on the south end a cofferdam for the south half. On the abutments we plan to connect the second half of the cofferdam to the stonework of the first half by means of a piece of timber or something cut irregularly to fit the stone, and then packed with rubber hose or something of that kind.

A MEMBER: Would it not be possible to build the abutments in two halves and then hold back the fill between them by an arch or slab?

MR. PAGON: We thought it would be most economical not to attempt any arching of the structure, because an arch of that kind in the sea water would have to be faced with stone, and it would be rather a complicated proposition. I may not have brought it out emphatically, but all of the foundation between extreme low tide and one foot above the highest recorded tide, will be faced with coursed granite one foot thick. On the bascule piers where the walls are thin, and where this stone facing can be only six to eight inches thick, every stone will be anchored back into the concrete with two or more wrought iron clamps, so that no water can get in behind and force off the facing. On the other piers it will be bonded right into the concrete.

A MEMBER: Do you cast the floor solid with girders?

MR. PAGON: The plan is to cast the girders first. It simplifies the removal of the forms. The steel frame then will only have to carry the dead load of the girder itself, and not the dead load of the superstructure.

A MEMBER: You must have to put considerable steel in to take the compression?

MR. PAGON: Occasionally we do. In this bridge the steel is continuous over piers. We have some little compression steel, but the concrete is designed to carry all the compression, except in one or two cases, and, of course, exclusive of the compression, due to erection load of the girder and forms, which is carried by the steel alone.

MR. CRAM: The question of design brings to mind the feature of the location of the street railway tracks, whether they should be in the center or one on each side of the roadway. I bring this up because I was asked a short time ago by a consulting engineer what I thought of locating the tracks one on each side of the roadway on a bridge of about this width. I told him I objected to any such method; that it had been determined around New York on the bridges over the East River that it was better to have the two railroad tracks located in the center of the bridge, because it is the faster moving traffic, and the automobile traffic can follow, leaving the slower moving traffic on the right.

Mr. Pagon: I think I am safe in saying that very few bridges have been built in the last few years where the tracks have been anywhere but in the center. Perhaps it is only a matter of custom, but in the majority of city streets the tracks are in the center, and I think this custom has governed in bridge design more than anything else. Of course there *is* the reason that the fast moving traffic is in the center; and therefore it is probably better to have the trolley tracks there.

Mr. Cram: I wondered whether there are any particular rules whereby one could determine which would be the most advantageous?

Mr. Pagon: A bridge is in the same class as a residential street. That is, there are no vehicles that stand along the curb. It would be just as easy to put the tracks at the curb of a bridge as on a residential street. There is really no reason against it. I don't recall, however, any recent bridge that has been built that way.

Mr. Terry: You spoke of a possible change in the railway structure across the lower end of Fairfield Avenue. What sort of a change have you in mind?

Mr. Pagon: We showed on our plan a picture of the structure as we would like to see it; not as it is now.

A Member: Do you mean to leave out any of the present piers?

Mr. Pagon: No. We don't contemplate leaving out the present piers. We wished simply to show what could be done with the structure. It has been done elsewhere. For instance, the elevated railway in Boston, where it crosses one of the parkways, has been encased in concrete supported on expanded metal. That might be done. That is the type we have shown in the plan.

A Member: About removing the center pier?

Mr. Pagon: It would be feasible to lower all of the piers down to the sidewalk level, and put in a bent of concrete. It would not be feasible to eliminate the center pier, because then an unsightly through truss bridge would be required.

I didn't bring out one point—that is, we have relocated the street car tracks on the west end, so that the east-bound track is to the north of the center pier of the railroad bridge, and the west-bound track is to the south of it, hence the traffic will be handled much better than it is now. The governing condition was that all west-bound traffic on the present approach has to cross over the tracks several times, whereas in the new approach the west-bound traffic will cross no tracks until it comes to Water Street; then will only cross the tracks that turn up into Water Street. Hence, there will be a minimum of crossing.

MR. BENNETT: What is the proportion of the cost between the bascule and the piers supporting it?

MR. PAGON: I am a little bit at a loss to answer that. You mean the bascule and the foundation supporting it. The bascule piers are worth—I can only give you an approximate figure, not the exact figures—one hundred and thirty thousand dollars altogether; that is, up to the roadway; the bascule itself is worth a hundred and ten odd thousand dollars; so that the bascule portion of the bridge is worth pretty nearly $240,000.

MR. BENNETT: Almost half of the total cost?

MR. PAGON: Nearly that. The whole bridge when finished will cost between $400,000 and $500,000, complete.

MR. CRAM: How much did the original bridge cost?

MR. PAGON: I don't know that. It was built in the eighties.

A MEMBER: What royalty do the bascule people get?

MR. PAGON: The bascule people will never tell you just what their royalty is. I happen to know, approximately, what they get, but perhaps they wouldn't thank me to tell you. They claim that the royalty is made up by the saving they effect in the type.

A MEMBER: Of course you select the type you want?

MR. PAGON: There are three types that are satisfactory, the Rall, Scherzer and Strauss. We have built all three types and found them satisfactory.

A MEMBER: That is the Strauss type?

MR. PAGON: This one is the Strauss type; yes.

THE INFLUENCE OF THE STREET, AS A LOCATION, UPON STREET RAILWAY TRACK MAINTENANCE.

By R. C. Cram, Mem. Conn. Soc. C. E.

The maintenance of street railway tracks presents a number of problems not found in the maintenance of steam and electric railroads located upon private rights-of-way. The word street directs us to the principal reasons for this statement, but while this is a simple word the conditions it represents lead to many complications in the construction and maintenance of tracks when the street is used as a location, and while there occur the same principal components of a track structure as in the steam railroad, they are installed and maintained under conditions which require altogether different treatment.

The needs of modern surface transportation have developed the comparatively simple street railway track of the horse-car days, which required little or no maintenance, as we now apply the term, into a structure requiring the best efforts of the maintenance engineer, who is himself a specialized development in a line of engineering work, created by the growth of the electric street railway industry. The importance of the work undertaken by such engineers becomes more evident when it is realized that there are now 1,027 electric railway companies in the United States alone, operating over 46,000 miles of track and almost 100,000 cars. The maintenance of this trackage at $900.00 per mile per year shows an annual expenditure of $41,000,000.00.

At the present time the street railways are in a period of reconstruction, which may be considered as extraordinary maintenance, because comparatively little added capital is involved. New construction is almost at a standstill and only comprises occasional extensions to existing lines. This period of reconstruction began about eight years ago and the trackage which has undergone reconstruction has increased annually ever since.

I have referred to the complications incidental to the maintenance of street railway track structures and it is important to enumerate some of the principal factors of the problem, which are as follows:

1 Pavements.
2 Street widths.
3 Street and car traffic.
4 Grades and drainage of streets.
5 Street improvements.
6 Sub-surface structures.
7 Special forms of switches and frogs.
8 Regulatory bodies or civic authorities.

With respect to these factors it will be noted that generally they seldom occur in steam railroad work. Before considering them individually it may be remarked that the location of tracks in streets renders the railway subject to many complaints from the general public, and the entire operation continuously invites accidents of various kinds. On the other hand, those railroads located upon private way seldom come in contact with many of these conditions. Such roads can at least select their own rails and other features of track construction but the street railway can very seldom do so without consulting municipal or state authorities, and it quite often happens that the types of rails are legislated upon the street railways with little consideration of the railway's interest in such matters. In this condition of affairs we often have to take what these authorities give us and be thankful the situation is no worse.

Probably the most important feature affecting street railway maintenance is the pavement in the tracks, which in the first place accounts for between 40 and 50 per cent of the construction costs, and at least 30 per cent of the maintenance expenditures.

With respect to maintenance expenditures for pavements it may be remarked that they have generally been legislated upon the railways either through franchise requirements or in some cases by foolish agreements made by early operators and promoters. There may have been some justice in requiring a horse railway company to maintain track pavements, and it is generally agreed that the extraordinary pavement wear by the horses was the basis upon which this requirement was grounded. The electric street railways have inherited the obligation and although they put no wear upon the pavements, they are still required to construct and maintain them, and such an obligation to-day greatly increases the burden because of the great improvement and cost in street pavements over those existing at the time such obligations were imposed.

The width of the street in which tracks may be located and its character, with respect to whether it is in a residential or business section, have a marked influence upon the methods to be employed in carrying out maintenance work, as these factors determine the length of work which may be opened up and the distribution of materials so as to permit their handling in the most efficient manner. The latter is important because in narrow streets it is often found necessary to dispose of excavated material, with incidental handling under car traffic, at inopportune times, which in turn considerably increases the cost, in order to provide room for other classes of materials required in later operations.

In the work of reconstruction the street and car traffic have a considerable influence upon the manner in which the work shall be done and a careful examination of the street is always necessary in order to determine the proper course to pursue in the regular program for the work, and such traffic conditions must necessarily determine whether the work shall be done under car traffic at all times, which is probably the most expensive, or by single tracking, accomplished by means of temporary crossovers, or by the installation of a third or temporary track. The selection of method of carrying out the work affects the labor costs materially, because certain car and team traffic conditions, where tracks may not be put out of service for over six or seven hours per day, will often result in the loss of one-third of the effective labor, due to time lost in avoiding cars and vehicles.

The drainage of streets has a peculiar influence upon the maintenance of track structures, and long, easy grades, upon which surface water moves slowly or is retained for a considerable time, create conditions which allow more time for seepage of water into the pavements and sub-structures, and water is one of the principal agents in causing damage to both pavements and track structures. The importance of correct street grades and contours which allow rapid drainage of surface water away from the track, together with the installation of surface drains in the tracks at low points, cannot be emphasized too strongly. If the drainage is neglected a higher maintenance expense for all parts of the track structure may be expected. During reconstruction work much delay is experienced in wet weather because of the long retention of water in the sub-grade of the trenches, which requires a period of waiting until the roadbed shall have dried sufficiently to warrant the continuation of the track installation. The influence of the surrounding pavement in forming trenches of this character, where the pavement acts as a form of dam, presents a feature in connection with the maintenance of tracks in streets which is not present in maintenance work upon private way. In the latter case, the roadbed is open and readily drained, so that comparatively little trouble is experienced from the retention of water in the roadbed, and consequently there is little delay in the progress of work as a result of inclement weather. These delays are reflected in the operating costs of the transportation department, which are chargeable to the track work.

Street improvements, especially those requiring repavement or grade changes, are productive of much additional maintenance expense, because the railways are often obligated to install new pavements jointly with the city improvement. This requires either a most thorough overhauling and regrading of the tracks, or their complete renewal, which more often occurs. The greater part of such expense becomes a maintenance charge and must be deducted from income. Thus the maintenance for reconstruction or overhauling in connection with such improvements is advanced several years before it would normally fall due, adding greatly to the average annual maintenance expense generally without much influence in decreasing later expense for the following years when considered in connection with the entire trackage which is in operation. Such improvements, therefore, require close coöperation with the municipal authorities, in order that the best interests of both parties may be served, and it is now a general practice for the respective engineers to consult early in each year for the purpose of preparing programs and budgets which will work together as far as possible.

Sub-surface structures, such as sewer, water, gas, telephone and electric mains, have quite a direct bearing upon the surface track maintenance costs. City sewer and water departments have a habit of rebuilding, relocating or repairing their mains, and many of them are either directly under the tracks or very close to them, and they all have connections, at frequent intervals, which pass under the track. There is always a question as to how long a new track will remain undisturbed by work required upon some one of these sub-surface structures. The railway is often required to remove one or both tracks incidental to such work, and house connections are constantly being made which either require tunneling under or openings through the tracks. These features alone add greatly to the maintenance costs, and additional maintenance may be expected later, even after the first restoration, due to subsidences following such work, which generally falls upon the railways.

The special track work, such as switches, mates and frogs, used in street work, are quite different from the types used in roads located upon private way. In addition to being much more expensive in first cost they are subject to proportionately greater wear from car traffic and additional wear from vehicular traffic and, due to incidental disturbance of pavements, the installation and repairs are very costly. Owing to the street location, the frogs and other pieces are usually provided with renewable parts at points undergoing excessive wear. Such parts are subject to peculiar troubles and require constant attention with special equipment for their proper upkeep. Noise, in operation, plays a large part in connection with the maintenance of such special work, and much labor is expended in grinding joints, in arc welding and grinding hard centers, and in replacing parts, in order to satisfy complaints arising from this source.

Upon most systems in large cities there will be found a large number of such special work layouts in proportion to the total track mileage, and this proportion is much greater than that found in roads upon private rights-of-way. Consequently the number of parts involved which will require the attention of maintenance forces is extraordinary, and most systems have one or more gangs almost constantly employed in repairing or replacing special track work. Further, in large cities, emergency crews are maintained for the prompt repair of switches, so as to minimize the effect of their failures upon the car service, and these gangs are often provided with automobiles so that they may reach the sources of trouble as promptly as possible.

The cost of such special track work is very high. This is due to the high standard of construction required, generally involving the use of large amounts of manganese steel. The cost is also increased by the great variety of locations, street angles, controlling street widths, and the types of cars in operation. A great many of the frogs will suit only one location, and it has so far been deemed practically impossible to standardize them so as to permit a reduction in cost through the elimination of a great many special patterns. However, considerable study is now being given to the subject and it is possible that ultimately their number may be decreased.

Within a very few years there has been a marked increase in the number and powers of regulatory bodies or civic authorities. In New York City, for instance, there are at least eight of these and each has much to say in controlling maintenance work, with considerable overlapping of authority. We have the Bureau of Highways, the Department of Water Supply, Gas and Electricity, the Bureau of Sewers, the Board of Health, the Board of Estimate and Apportionment, the Department of Street Cleaning, the Police Department and the Public Service Commission. They tell us under the provisions of laws and ordinances to repave streets; to take out tracks for sewers; to stop noise at joints and special work; to remove snow; to keep traffic open; to rebuild tracks and many other things. It seems, sometimes, during a busy summer season, as if everyone laid awake o' nights thinking up things to write and complain about, and there are often more or less direful penalties of fines and imprisonment for failures to comply with entangled and overlapping orders. Consequently, it has been found necessary to maintain a regular force of inspectors, who investigate such orders and complaints, so that we may determine their reasonableness and properly plan our work in compliance therewith.

The regular maintenance work of a large system, as distinct from reconstruction work, requires careful planning. As an aid to this, many systems now make annual inspections of their modern or standard tracks, paying particular attention to the three features which contribute most of the troubles. These are pavement, rail joints and rail corrugation. The inspections are rendered quite easy by the use of special report forms upon which the items may be entered and located by house numbers, cross streets and pole numbers, in order to facilitate their later location by the various working forces. The areas of defective pavement, number of defective joints, and lineal feet of corrugated rail are then tabulated from the inspection reports in percentages of the grand totals of each item in the territory inspected. These percentages render the task of making a program of work quite simple, as it is only necessary to select the territories having the greatest amount of defects for the first and most important work of each kind. By this means we are also able to tell, in comparison with previous years, whether we are keeping up with the work, and where special effort is needed.

Such inspections are also simplified by the use of plans made on letter-size sheets which give the details of the type of construction upon each particular street. Each street or section of street is given a section number, which is also indicated on the plan, and all costs for work done are charged against the various sections in sufficient detail to cover the main items, which are productive of maintenance expense, so that we may know how much we are spending upon our modern tracks for these features. Information drawn from a comparison of these expense items enables us to learn what the various modifications from standard construction are costing, and serve to point out what to avoid in future work. It is quite safe to say that had such information been available in Brooklyn seven or eight years ago some of our most expensive maintenance items on certain tracks would be about one-half what they are at the present time. We have also been able to determine that approximately one-half of the total paving maintenance expense, upon our standard tracks, has been due to an unfortunate experimental repavement in the roadways which was undertaken by the city upon one street alone, while over one-half of the joint maintenance costs was due to the type of joint on the same street and upon three others. It is hardly necessary to say that we have abandoned that type of joint, and we would like to be able to avoid such costly city experiments in pavements.

Rail joints have been mentioned as an item which cause high expense for maintenance. The early types of joints, particularly of the bolted variety, and many experimental forms of joints, have contributed an unreasonable share of the expense for track maintenance. However, the general adoption of sixty-foot rail lengths for modern tracks is rapidly tending to cut such expense in half. Furthermore, there are now several kinds of welded joints, at least two types of riveted joints which provide head and base support, and at least one type of patented bolted joints, all of which are showing marked decreases in costs for maintenance, and even the simple bolted joint has undergone such improvements in design as to render it much more serviceable.

Mention has been made of the importance of the pavement in street railway tracks, and it may not be out of place to give some information, roughly compiled because of lack of close data, showing the amount of pavement involved in the maintenance of street railway tracks in Brooklyn. Out of the total trackage there are approximately 500 miles of single track in paved streets, requiring the maintenance of approximately 2,640,000 square yards of pavement. This pavement would have a value, at an average cost of $2.50 per square yard, equivalent to $6,600,000.00, and this investment is constantly increasing as the city grows and requires paving improvements in tracks which are already paved in some form and where roadways outside are as yet not paved.

The above yardage of pavement is equivalent to the average state highway eighteen feet in width and 250 miles long, or of a street pavement thirty feet in width and 150 miles long.

It is understood that there are approximately 850 miles of paved streets in the Borough of Brooklyn and from this it appears that the street railway company maintains approximately 18 per cent of the total paved street mileage within the borough.

In addition to this, enough paving is installed or reconstructed in tracks yearly to build a street pavement thirty feet in width and from seven to nine miles long, and it has also been found that the street railway maintains an average of 50 per cent of the pavement in the streets in which it operates, and this percentage will probably hold good for most street railways in the average city situated in the eastern part of the country. The importance of this statement becomes more apparent when it is remembered that the property owners in New York are assessed for the cost of all new pavement and the property on each side bears the cost to the middle of the street; consequently upon all streets occupied by two tracks their assessments for pavement are cut in half and, further, the city is at all times relieved from the maintenance burden of one-half of the total paved area after its installation. Incidentally, and as a matter of timely interest, most street railway systems are required to remove snow from the track area, at least in the business districts, and in Brooklyn the present program of snow removal requires the clearing by the railway of 1,600,000 square yards of surface. The annual amount of expense for this work naturally varies and may run as high as $150,000.00.

The various branches of street railway track maintenance work require large investments in special tools and machinery designed for the purpose of reducing labor costs, and such investments will probably run from $125.00 to $150.00 per mile of single track.

In conclusion, it may be stated that while there has been considerable matter published upon the subject of economical maintenance of street railways tracks, but little has been said concerning the economics of maintenance, and there is room for much more careful consideration of the fundamental laws and principles involved than has so far been given to the subject. For instance, it may appear to be economical to open a track pavement at a joint only so much as is required to give the necessary working space, yet this procedure may not be in accordance with the true economy involved, because with certain types of pavement it has been found that the better method is to open an area much larger, which, in the end, can be repaved more quickly, more satisfactorily, and at lesser cost for paving labor. Just so it may appear to be economical to continue keeping rails in service because they have not fully reached the ultimate wear life indicated by the head measurements, yet it may be necessary to spend so much on repairs of various kinds, such as joint repairs and grinding corrugated rails, with the incidental paving expense, that the true economics of the situation will show that the actual rail renewal is required.

These illustrations serve to call attention to the statement previously made to the effect that there is room for more careful consideration of the fundamental laws and principles governing street railway maintenance.

DISCUSSION.

QUESTION: What is meant by rail corrugation?

MR. CRAM: For purposes of illustration I will use the blackboard and chalk for a few moments. The street railway rails in a good many cities are grooved girder rails of some form. These rails are subject more to this matter of corrugation. The corrugations are forms of ridges which appear after a certain length of time upon new rails; and very often upon old rails. They have the appearance of a form of waves (illustrates). We have ridges which form something like that. Show bright spots, at an angle of about thirty degrees from the right angle, from 90 degree line with the gage. Those angles will take about 30 degrees. They have a regular synchronous form. They present one of the most serious problems we have to-day in connection with the rails. In new rails we have had them within five months begin to show corrugation, in Brooklyn; in about ten months that ridge developed and required grinding.

QUESTION: How about the T rail?

MR. CRAM: Occasionally, but not in so marked degree. However they have corrugations in T rails in some railways in the subways and on the elevated lines. We have had only girder rails in greater New York in the surface work.

QUESTION: Do they repeat after once grinding?

MR. CRAM: On the matter of repetition in general it may be stated that once we have successfully ground them out they do not very often come back. Occasionally they will come back in a very slight degree, and then disappear after a while. In grinding, if you do not grind them carefully enough to get some form of an angular inclination which suits the wear of the main portion of the rail and the average wear of a wheel pretty well, the worn wheels will come on certain parts which present surfaces in a new place as new subjects for wear, and they will of course corrugate. Occasionally we have to go back and touch them up.

This corrugation, as I said, is something that no engineer has been able to tell us the cause of. There are as many theories about what causes it as there are people in this room; and that is some.

THE CHAIRMAN: Do germs have anything to do with it?

MR. CRAM: I should rather think they do.

QUESTION: Are the corrugations uniformly distributed?

MR. CRAM: No respecter of locations. You find them in one place and under one set of conditions, and the other fellow tells you he finds them under conditions exactly the reverse. You may find it on one rail and not on the opposite rail. If, however, the corrugation has been allowed to remain on the rail opposite to that free from corrugation, it will transmit itself over to the rail that was free from corrugation. That presents a problem. Where does it start? How does it get from one place to another? You have it on one rail and not on the other; after a while you find it has got over there. How did it get over there?

MR. WILSON: Have you made any analysis of the depressions?

MR. CRAM: They have been made in several different ways; by the method of taking magnified photographs; micro-photographs as they are called; and by the various etchings with acid; tests for hardness, such as the Brinnell tests. The difference, if any, in hardness is so slight that it can not be ascribed to that at all. The particular puzzle is whether it is in the crest or in the hollow of the corrugation.

MR. WILSON: Have you ever noticed that one particular sixty-foot length would corrugate and the other rails making up the same track would not corrugate?

MR. CRAM: Yes.

MR. WILSON: It occurs to me it is then a matter of process of elimination?

MR. CRAM: The thing you try to eliminate is the corrugation. Now, then, it has been my idea to a certain extent that among other things the rail itself probably has a good deal to do with the situation. How much I cannot say. Take any number of rails, examine them as closely as you can; take a templet, set it over the head and slide it along; you won't find enough variation so that you can see daylight under the templet as you slide it along looking toward the light. That rail may become corrugated just the same. There may be steel conditions of twist in the web or infinitesimal differences in shape which you cannot find which in themselves have something to do with it. It is an open question. I have some ideas of my own about it. I have had a theory—it is nothing more—but I have accepted it in my mind for trial; and that is, that the question of the design of the rail, particularly with regard to the rail head, curved head as against a plane head, may have something to do with it; because it is well known that in street railway work at least there is a less amount of corrugations on T rails used in street work than in girder groove rails used in street work. That has been ascribed to the fact that the ordinary T rail has a curved head of about a twelve-inch radius, while the ordinary tram girder and grooved girder rolled until very recently has a plane head with a slope of about one degree and thirty minutes down from the horizontal. That slope is designed to conform to the coning of the standard car wheel. I don't think there are one per cent of all the wheels on 2,000 cars having four wheel trucks that hold their contour any length of time. You can go out on the Connecticut Company's lines and find the same thing. Look at the wheel. When it came out of the shop from the manufacturer it looked like that (illustrating). Steel wheels or any kind of wheels—it is full of these things (illustrating).

Mr. Wilson: In the grinding of these wheels their diameter is changed. Very often the diameter of one wheel on the axle is different from the wheel on the other end. One wheel will travel faster than the other. I wonder what effect that would have?

Mr. Cram: I think most modern mechanics nowadays try to mate things up more than they used to. Comparatively slight differences, as in the diameter, at first thought would not seem to have much to do with it. But we have a peculiar thing called the nosing of cars, swaying back and forth—some engineers question how much influence that may have, in conjunction with this whole problem, as tending to show that there is some synchronization perhaps due to conditions which set up an oscillation back and forth in this way, which in turn forms some kind of a vertical movement this way (illustrating). These crests generally come about two and a half to three inches on centers. Movement this way, with a kind of an oriental wiggle. About 22 per cent of our maintenance expense on modern standard track in Brooklyn is due to corrugation.

Question: How much trouble do you have through trenches being dug under that part of the track for which the street railway company is liable?

Mr. Cram: A great deal of trouble comes from that source. It is one of our principal maintenance problems—keeping track of those things. We have in our system one man whose sole duty is to run around and inspect those things; look at the permits to see that they are authorized to do the work; follow the work and see that restorations are properly made; also to make a record so that we may answer the city's man when he comes around and asks questions. In Brooklyn the digging up for sewers is a big subject. Last year they put a great big relief sewer under us; fifteen feet wide, twenty-five to forty feet underground; we had to take up both tracks for a mile, on one street, and three-quarters of a mile on another. It seems as though they deliberately pick the railway streets. In talking informally with the sewer engineers they told me that they could probably have picked another location which would have only crossed the tracks at three or four places; they did not absolutely need to take the railroad street location, and they could have gotten practically as good conditions for their sewer and the railroad would have been relieved from apparently unnecessary and heavy expenditures which could better be applied toward track and pavement betterments. We are not complaining. We have a street railroad operating on the streets, and we have to do as the law requires.

SUMMER MEETING.

The Summer meeting of the Connecticut Society of Civil Engineers held August 11 at North Branford was marked by the largest gathering in the history of the Association. About 150 members and guests from all parts of the State attended. The affair was a great success.

A special car furnished through the courtesy of the Connecticut Company and leaving the New Haven Railroad Station at 9.45 A. M. carried the members to the terminus of the Branford Steam Railroad of the New Haven Trap Rock Company. An inspection of the tide-water terminal was then made, after which a special train was furnished to take the engineers over about seven miles of quarry railroad to the site of the plant in North Branford. For the benefit of the Society, Mr. Clarence Blakeslee arranged the shooting of an immense blast of rock; the volume of the blast was about 10,000 or 12,000 tons. An inspection of the quarry plant was then made. This is one of the largest plants of its kind in this section of the country. After the inspection of the plant the association entrained for an investigation of the commissary department. A clambake was served prepared under the direction of Captain Tom Scott who lived up to his reputation as the man who knows how.

In addition to the entertainment afforded by the Second Regiment Symphony Band, the special features of the day were: splendidly rendered selections by the quartette: P. Ney Wilson, Francis Hamilton, Francis Lincoln and George Basserman, and an exhibition of toe dancing by R. C. Cram.

Directly following the clambake, President C. C. Elwell called a business meeting, at which the following persons were elected members of the society: William M. Bolton, New Haven; Robert N. R. Chaffee, Meriden; Henry W. Geer, Middletown; John C. Glynn, New London; Bernard Greenberg, New Haven; George E. Hamlin, Hartford; Cyrus P. Howes, New Haven; Clifford A. Peck, New London; Jeffrey O. Phelps, Simsbury; John P. Quay, New Britain; Caleb M. Saville, Hartford; Erwin W. Schrewe, Bridgeport; Harry T. Williams, Waterbury.

The following amendments to the constitution and recommendation from the Board of Direction were adopted:

ARTICLE III.

OFFICERS AND THEIR DUTIES.

OFFICERS.

SECTION I. The officers of the Society shall be, a President, two Vice Presidents, a Secretary and Treasurer, an Assistant Secretary, and four Directors, one of whom shall be the last living Ex-President.

ELECTION OF OFFICERS.

SEC. 2. The officers, excepting the Assistant Secretary and the Director who is the last living Ex-President, shall be elected at the annual meeting, and shall hold their respective offices until the final adjournment of the meeting in which others are elected and qualified in their places.

BOARD OF DIRECTION.

SEC. 8. This Board shall consist of the President, the two Vice Presidents, and the four Directors. It shall have supervision and care of all the affairs of the Society and shall conduct the same in accordance with the Constitution and By-Laws. The President or one of the Vice Presidents shall preside at all meetings of the Board in the order of seniority. In the absence of all these officers a chairman *pro tem.* may be appointed for the meeting. At the annual meeting in February, 1916, only one Director shall be elected, to serve for one year. At the annual meeting in February, 1917, three directors shall be elected, one to serve for one year, one to serve for two years, and one to serve for three years; and at each subsequent annual meeting one director shall be elected to serve for three years. A Director elected at and after the annual meeting in 1917 shall not be eligible for reëlection to any office until one year after his term of office has expired. At the annual meeting in 1917, the person receiving the highest number of votes shall be the director for three years, the one receiving the next highest number of votes, the director for two years, and the one receiving the next highest number, the director for one year. In case of a tie vote, the terms of office shall be decided by lot. Four members shall constitute a quorum to transact business.

ARTICLE IV.

ELECTIONS.

OFFICERS, WHEN ELECTED.

SECTION I. At each annual meeting the Society shall elect by ballot, a President, two Vice Presidents, a Secretary and a Treasurer, to serve one year. At the annual meeting in 1916, a Director shall be elected to serve one year; at the annual meeting in 1917 three Directors shall be elected, one to serve one year, one to serve two years and one to serve three years. At each annual meeting after 1917 one Director shall be elected to serve three years.

ARTICLE V.

MEETINGS.

ANNUAL MEETINGS.

SECTION I. There shall be a *regular annual meeting* held on the third Tuesday of February of each year, at such place as may be selected by the Board of Direction, of which due notice shall be given by the Secretary.

At the last annual meeting of the Society, the Board of Direction was instructed to prepare and present to the Society, at its summer meeting, an amendment to the Constitution eliminating the office of Second Vice President.

Your Board respectfully begs leave to report that it has carefully considered this matter but, in view of the fact that such an amendment is in direct conflict with another amendment which the Society, at the same meeting, instructed the Secretary to submit to the members for a letter ballot, the members of the Board are unanimously of the opinion that it would be unwise to submit this question to the members for a letter ballot at the present time.

Your Board would therefore recommend that the action of the Society, relating to the elimination of the office of Second -Vice President, be rescinded.

Votes of thanks were extended to the Connecticut Company, Shore Line Electric Company, New Haven Quarries Company and Captain Tom Scott.

A baseball game between the Hartford and New Haven contingents was won by the local nine 12 to 0.

The athletic events following the baseball game were: Three-legged race, sack race, shoe race, potato race, fifty-yard dash, obstacle race, hop-skip-and-jump, pitching quoits and throwing the discus.

To those in charge of the arrangements for this outing is due in a large measure its marked success.

AUGUSTUS JAY DUBOIS.

Mem. Conn. Soc. C. E. Died October 19, 1915.

In the death of Professor DuBois the Connecticut Society of Civil Engineers loses one of its most distinguished members. To the many members of this Society who were numbered among his students the loss is peculiarly a very real and personal one.

Augustus Jay DuBois was born April 25, 1849, was graduated from the Sheffield Scientific School in 1869, was awarded the degree of civil engineer in 1870 and the degree of doctor of philosophy in 1873. Later he studied mechanics for two years at the Mining Academy in Freiburg, Saxony, and from 1875 to 1877 he was Professor of Civil Engineering and Mechanical Engineering at Lehigh University. In 1877 Professor DuBois was appointed Professor of Mechanical Engineering in the Sheffield Scientific School and in 1884 was transferred to the Professorship of Civil Engineering, where he remained at the head of the Department of Civil Engineering until his death. Thus for thirty-eight years he was a member of the Faculty of the Sheffield Scientific School and of its Governing Board.

Professor DuBois was the author of some of the best-known treatises on mechanics and stresses in the English language. His book on "Graphic Statics," published in 1876, was largely instrumental in introducing to American engineers the graphic method of determining stresses in framed structures now so widely used. This was followed by his translations of several important German treatises in different branches of mechanics and later by his own elaborate and original book on "Strains in Framed Structures" (1883), perhaps the first comprehensive treatment of the subject in English, and a book that took its place at once as one of the most important contributions to engineering literature. A series of books on mechanics culminated in his "Mechanics of Engineering," published in 1901 as one of the series of volumes issued in connection with the Bicentennial Anniversary of the founding of Yale University. In addition to technical treatises, Professor DuBois contributed many essays to current periodicals, the last of which, on "The Religion of a Civil Engineer," appeared in the Yale Review issued in July, 1913. These essays were marked by a style beautifully clear and forceful and by a logic so perfect that, granting his major premises, one was led almost irresistibly to his conclusions.

Professor DuBois was the great-grandson of John Jay, the first Chief Justice of the United States, and he seemed to have inherited the sterling qualities of that remarkable jurist and statesman. He had the same serene dignity, the same self-reliance and self-control, and the same aversion to saying more than was necessary. He was a clear and original thinker, and a keen but sympathetic critic. Breadth of culture and an unusual power of expression made him a brilliant and inspiring conversationalist.

Those who knew Professor DuBois intimately will remember always those more charming characteristics which won their love as well as their respect. Underneath a quiet and undemonstrative exterior there was a man chivalrous, sympathetic, always thoughtful of others, loyal, and wholly lovable. His keen sense of humor continually bubbling over in a merry twinkle of the eye and in a wit refined, spontaneous, and without sting, was a constant source of delight. Only a few of his closest friends knew how in his own quiet, unostentatious way he went about doing good, and to them he seemed an almost perfect type of Christian gentleman.

In June, 1915, Professor DuBois wrote a letter to one of the classes which was holding its twenty-fifth reunion. This letter was not intended for publication, but its closing paragraphs reveal so well his character and ideals that they may be appropriately quoted here:

"Let me give you just one thought that my life seems to have brought me. We speak of the 'pursuit of happiness.' It seems to me a mistake The man who pursues happiness never overtakes it. From such an one happiness ever flees temptingly just out of reach. Just keep on the job during every day; do a man's work for home and country, and happiness will pursue you. Happiness is a by-product. I wonder if you have not found it so.

"Another thing is that the best work for every man is the work of *service*. Not 'what can I *get*,' but 'what can I *give*'! That has ever seemed to me the attitude which gives to life its zest and value. I wonder if you have not found this so. If you have, then men of '90, your feet are set aright, and when old age tackles you you can look back and smile, for you will find you have walked hand in hand with happiness and success.

"Success! Yes, even though your actual performance may be slight; only so that it is your best and done for others—*service*. It is the will that counts.

"'Not failure, but low aim, is crime.' And so, men of '90, drink deep while here of this 'Yale Spirit,' take it with you as inspiration and encouragement, and take with you best wishes for all.

"Hail and farewell."

(Signed) AUGUSTUS JAY DUBOIS.

Memoir prepared by
J. C. TRACY,
S. E. BARNEY,
CHAS. S. FARNHAM.

JAMES K. WILKES.

Mem. Conn. Soc. C. E. Died January 8, 1916.

James Knapp Wilkes was born at Danbury, Conn., August 21, 1859. He was educated in the public schools of Danbury and the State Normal School at Albany, N. Y. In 1880 he entered the engineering office of Mr. Penfield at Danbury, Conn. He was Danbury's first city engineer and remained there until 1890 when he went to New Rochelle, New York, as assistant engineer of sewers. In 1891 he was reëlected city engineer of Danbury and held that office until 1893, when he returned to New Rochelle as Chief Engineer of the Sewer Commission. He remained in the service of New Rochelle as engineer of sewers and as city engineer continuously until 1912, except for the three years from 1900 to 1903, which were spent in street railway work, in New York City, the construction of cadet quarters at Annapolis and a private railroad at Middletown, Conn. He went to Porto Rico in 1912 on work connected with the construction of government and municipal buildings. On his return in 1913 he organized the Wilkes-Casey Engineering and Contracting Company, in New Rochelle, and was its President at the time of his death, January 8, 1916.

Mr. Wilkes was a member of the American Society of Civil Engineers and a charter member of the Connecticut Society of Civil Engineers. He was an able engineer and a fine type of man and citizen. In private life he was most genial and companionable and his death brings to the older engineers of the State a feeling of great loss both personal and professional.

Memoir prepared by

S. E. MINOR,
C. H. BUNCE,
T. H. McKENZIE,
Members Conn. Soc. C. E.

PROCEEDINGS

OF THE

THIRTY-SECOND ANNUAL MEETING

OF THE

Connecticut Society of Civil Engineers

Morning Session—Tuesday, February 15th.

Meeting called to order at 10.30 by President Elwell.

President Elwell: I have appointed as tellers for the election of officers Mr. Turner and Mr. Trumbull.

It was voted to approve the minutes of the last annual meeting as printed in the annual report.

Report of the Board of Direction read by Secretary Jackson.

Report of Board of Direction.

At a meeting held in the Mason Laboratory, February 9, 1915, it was voted to refer the resolution concerning funds for State Parks to Committee on Legislation. A committee consisting of Messrs. Bush, Ferry and Kellogg was appointed to prepare and submit to the Board an amendment to the constitution concerning method of election and terms of officers. Resolutions to be presented by Committee on Legislation to the General Assembly is relation to acts affecting engineering, were read and approved.

The following applications were approved: George L. Bilderbick, Edward F. Bradley, Alfred P. Colgan, William R. Colgan, John N. Eckle, Herbert C. Elton, Samuel H. McKenzie, Reginald C. Meeker, George B. Pillsbury, James F. Mooney, Robert J. Ross, Paul B. Spencer, George B. Taylor, John J. Tucker, Frank M. Travis, William E. Walker, Joseph B. Whittemore.

Present—Crandall, Elwell, Blakeslee, Bush, Ferry, Kellogg and Punderford.

At the meeting of the Board of Direction held February 9, 1915, in the Hotel Taft, it was voted that the Committee on Legislation be instructed to use their judgment as to what to oppose and what to advocate in the bills relating to protection of water supply and sewage disposal, and in relation to the indexing of town records that they be instructed to advocate the general principle embodied therein.

At the meeting of the Board of Direction held February 10, in the Mason Laboratory, the resignation of R. F. Bennett was accepted, and nine (9) members were dropped for nonpayment of dues.

At the meeting of the Board of Direction held March 2, at 185 Church Street, it was voted to send out the annual reports before the summer meeting if possible; in relation to publishing the discussions of its business parts of the meetings, it was voted to just publish a skeleton outline of business transacted. A committee consisting of Messrs. Bush, Ferry and Punderford was appointed to consider methods of presenting technical papers and reports at the annual meeting; they to report at the summer meeting. The resignation of Mr. Ford of the Legislation Committee was considered and it was voted to ask him to reconsider it. A vote authorizing change in the wording of the amendment to constitution so that it reads "not to be elected to any office" was adopted. The resignation of Kershaw was accepted.

At the meeting held July 14, at the Colonnade, Savin Rock, it was voted to hold a summer meeting August 11, and to make an inspection of the New Haven Quarries Company at North Branford, the arrangements to be left to a committee appointed by the President.

Mr. Bush presented a progress report from committee on methods of expediting business at annual meetings.

Present—Elwell, Ferry, Blakeslee, Bush, Buck and Kellogg.

At a meeting held at North Branford, August 11, it was voted to adopt and present to the society a resolution concerning the office of second vice president. The following applications for membership were approved: William M. Bolton, Robert N. R. Chaffee, Henry W. Geer, John C. Glynn, Bernard Greenberg, George E. Hamlin, Cyrus P. Howes, Clifford A. Peck, Jeffrey O. Phelps, John P. Quay, Caleb M. Saville, Ernest W. Schrewe and Harry T. Williams.

At a meeting held at the Graduates Club December 4, it was voted to hold the annual meeting at New Haven and that it be a two-day session, arrangements to be left to a committee appointed by the President; that the price of tickets to the banquet be $2.50. Report from committee on expediting business at annual meetings received; voted to postpone discussion until Mr. Bush, the chairman, was present. Voted to notify delinquents that if dues were not paid by date of annual meeting they would be dropped. Voted that next meeting of Board be at Bridgeport, January 12. Voted that Board meet day preceding annual meeting to transact all business ready for it.

Present—Elwell, Kellogg, Ferry, Blakeslee, Punderford and Buck.

Meeting of Board of Direction in Hotel Stratfield, Bridgeport, January 12, 1916, 5.30 P. M.

Present—Elwell, Kellogg, Punderford, Buck, Ferry.

Canvass ballots for nomination of officers for 1916 resulted as follows:

President, Clarence Blakeslee; First Vice President, Henry R. Buck; Secretary and Treasurer, J. Frederick Jackson; Director, John K. Punderford, Frederick L. Ford.

No one person having received a sufficient number of ballots for nomination to the office of Second Vice President, the Board named Thomas A. Scott, W. R. Dunham, Jr., and W. H. Moore, they being the three having the greatest number of votes.

Messrs. Moore and Ford declined nomination.

Voted: To accept resignation of E. L. Chandler.

Voted: To defer matter of index of proceedings unless it appears that money is available.

Vote of thanks was extended to K. C. Walker for preparing index.

Voted: To recommend to the Society increasing dues to $4.00.

Report of Committee on Methods to be observed to expedite business at meetings of Society received and discussed.

Voted: That report be accepted as guide to officers.

Voted: To recommend to Society adoption of inset in paragraph 7 (attached hereto):

"It is recognized that some papers, or the parts of some papers, because of their mathematical or technical nature, are not suitable for presentation at meetings of the Society. Hereafter papers of this kind will be printed in the Report, but not presented at the meetings, except in such modified form as will be readily understood by oral presentation.

"Authors preparing papers are requested to inform the President of the Society in advance of their general character, length, etc., also whether or not lantern slides, drawings, or other illustrations will be used in the presentation."

Voted: To print paragraph 8 (attached hereto) in the annual report:

"The Board can with propriety adopt the following information for the assistance of those preparing papers. This can be printed in the Report, and reprints sent to members after it is known that they have started on a paper.

"The following information and rules regarding the preparation and presentation of papers is offered to authors by the Board of Direction with the suggestion that the same be followed, but at the same time the Board recognizes that frequent deviations are to be expected. It is believed that their general observance will add interest to our meetings and publication.

"Papers are desired which describe research work, novel construction or methods used, works of magnitude, or personal experience in solving engineering difficulties. Subject matter which has appeared in engineering papers, or which has been presented to other technical societies, had best be omitted. A paper need not be long in order to be good. Brevity is desirable but should not sacrifice essential information. Itemized costs and quantities are desired, also information on cost items which will explain their character, such as whether the work was done by contract, force account, etc., amounts paid for labor and materials, bid prices, etc.

"At the beginning of each paper should appear a brief synopsis of what the paper covers. Following this should come the conclusions, if there be such, derived from the experiments described, the arguments followed, or the experience gained, concerning which the paper is written. Use sub-headings freely, and divide the paper into component parts. Include, preferably at the end, the names of those who have been active in the design and construction of the work described. Interest in the subject will be heightened if to many papers of a certain kind is added a brief bibliography of similar matter to be found elsewhere, of authorities or authors quoted or used in the preparation.

"The maximum size of any half tone or line cut that will go in our Report without a special inset sheet is six and five-eighths inches high by four inches wide.

"In making half tone cuts some detail is necessarily lost. Hence a good photo is always needed for a good cut. A time exposure with a small stop is generally better than a snap shot, also pictures taken on cloudy days give better definition than those taken in the bright sun, as the latter have enhanced shadows which reproduce poorly. Prints made on glossy Velox or Solio paper make the best cuts. Adjusting the swing backs of view cameras, when they are pointed upwards or downwards, will prevent distortion of the vertical lines of the picture. Half tone cuts made from large maps or drawings seldom come out well and should be avoided if possible.

"Line cuts require the original to be a sharp, clear cut, black ink drawing on cloth or white paper. The lines, figuring and lettering, should be large and not crowded so they will reproduce properly in the cut. A reduction of ¼ to ⅕ of the original drawing will generally produce a cut easily read. The minimum height of lettering in a cut that can be read is about .056 of an inch. If a ⅕ reduction to a full page line cut is contemplated make your drawing not larger than 33 inches long nor 20 inches wide, and have the smallest letters not less than ¼ of an inch high. Hatching lines should not be closer than ⅛ of an inch.

"Lantern slides can be made from any good negative. If made from prints the cost is more as a print must first be made from the negative. Our Secretary will send the name of a good slide maker upon request.

"The standard size of lantern slides is 3¼ by 4 inches. A 'thumb spot' label should be placed at lower left hand corner of slide to guide operator in placing the slide correctly.

"Reflecting stereopticons will project (rather poorly) photos, printed pages, etc., if they can be placed in the machine. That at the Mason Laboratory, New Haven, will project an object 5⅛ inches high and 5½ inches wide, exclusive of the borders."

Meeting of the Board held in Hotel Bishop, New Haven, February 14, 1916.

Present—Elwell, Blakeslee, Buck, Punderford, Kellogg, Ferry.

Arrangements for the annual meeting were discussed and approved.

Resignations of Edmund Brown and Everit G. Lewis were accepted. Cases of delinquents were discussed and it was voted that the Secretary notify them by registered mail and report those not discharging their indebtedness to the next meeting of the Board.

The following applications for membership were approved: Thomas C. Atwood, New Haven; George T. Baldwin, New Haven; William E. Bernhard, Bridgeport; Raymond J. Brown, Bridgeport; Harold T. Burgess, Meriden; William H. Burns, Gales Ferry; Alfred H. Codaire, New Haven; Robert Allis Cross, Hartford; Earl T. Fenelon, Bridgeport; Chester F. Gailor, New York City; E. Selden Geer, Jr., Hartford; Robert N. Green, Darien; Jonathan T. Hart, Berlin; Orrin W. Head, New Haven; James N. Jensen, Bridgeport; Raymond E. Kelley, Hartford; Ruel H. Longden, Bridgeport; Edward A. McCarthy, New Britain; Frank McLaughlin, Bridgeport; George L. Mylchreest, Hartford; James A. Newlands, West Hartford; Peter K. Rask, Hartford; Burton Shook, Bridgeport; Ralph A. Smead, Hartford; Martin S. Steelman, Hartford; Edward J. Vaughn, Hartford; Alden Wells, Hartford; Joseph D. Williams, New Britain; Albert Louis Worthen, New Haven, for active membership, and C. H. Chapman, Bridgeport; Cyrus C. Chamberlin, Plantsville; Walter M. Jones, New London; John P. Maguire, New Britain; Raymond B. Whittaker, New York City, for associate membership.

C. C. ELWELL,
J. K. PUNDERFORD,
C. A. FERRY,
H. R. BUCK,
H. J. KELLOGG.
Board of Direction.

Motion made, seconded and duly carried that the report of the Board of Direction be accepted and placed on file.

Report of the Secretary read by Mr. Jackson.

REPORT OF THE SECRETARY.

To the Officers and Members of The Connecticut Society of Civil Engineers:

Your secretary respectfully submits the following report:

In July, 1,700 copies of the thirty-first annual proceedings were distributed to the members, to those societies with whom we exchange and to different libraries and institutions of learning. The demand for our publication is increasing each year and if it is met we must decide to increase the number of copies printed or cut out some of the societies with whom we exchange. For the past five years we have been running with an annual deficit of about $150. If we decide to increase our expenses for printing, some means should be provided to meet the increase. No economies occur to me which would not be detrimental to the Society; an increased return from advertising is not probable; there remains only one other way, that of increasing the dues, and I trust that the Society will take some action in relation to this at this meeting.

The summer meeting was held at North Branford, August 11, and a full account appears elsewhere. In addition the Society held five smokers, at New Haven, April 22; Hartford, May 6; New London, May 27; New Britain, December 10; and Bridgeport, January 12. These were conceived by President Elwell as means of increasing the membership and extending acquaintanceship among the members. They were all very successful, but the opportunity for greater development is apparent. The matter should not be left to the officers but should spring from the initiative of the members themselves, in the various cities. The Society is indebted to those members who helped along by their presence and by the free use of their talent, and to the Connecticut Company for the transportation it furnished.

The Secretary has, during the year, attended the different meetings of the Board of Direction, has had printed and distributed notices of the different meetings, bills for dues and advertising, and the ballots for nominations and election of officers. The canvass for nominations of officers resulted as stated in the report of the Board of Direction.

During the year twenty-nine active members have been elected and one associate; ten active members have been dropped and four active members have resigned. Two active members, Prof. Augustus J. DuBois and J. K. Wilkes, have died. The membership, February 15, is as follows:

	Feb. 9, 1915	Elected	Resigned	Dropped	Died	Feb. 15, 1916
Honorary	13					13
Active	325	29	4	10	2	338
Associate	16	1				17
	354	30	4	10	2	368

Report of Treasurer read by Mr. Jackson.

REPORT OF TREASURER FOR YEAR ENDING FEBRUARY 1, 1916.

RECEIPTS

To cash on hand February 1, 1915	$341.04
Received discount on bills (advertising, 1915)	13.90
Received from advertising, 1915	487.80
Received account of back dues	75.00
Received account of dues, 1914	168.00
Received account of dues, 1915	630.00
Received account of dues, 1916	63.00
Received account sale of dinner tickets	490.00
Received account sale of proceedings	6.52
Received account of sale of Society pins	11.00
Received account smokers	50.12
	$2,336.38

DISBURSEMENTS

By Freight	$ 13.32
Express	2.75
Society pins	20.00
Expenses of annual meeting	414.23
Expenses of summer meeting	172.70
Printing, stationery and supplies	966.87
Rent post office box	6.00
Postage	48.14
Engraving	139.04
Traveling expenses	1.84
Stenographer and typewriting	98.75
Telephone	.75
Smokers	44.30
Salary Secretary (balance 1914)	50.00
Salary Secretary 1915	150.00
Balance in bank February 1, 1916	207.00
	$2,336.38

The outstanding indebtedness is about $230 for printing for annual meeting and annual report.

Motion made, seconded and duly carried that the report of the Secretary be accepted and placed on file.

President Elwell: Is the Committee on Legislation ready to report?

Mr. Buck: As this is an off year with the Connecticut Legislature there is little to report. Your committee supported three bills at the last session. Mr. Jackson's Board of Health bill passed; as did Mr. Turner's State Park Commission bill. Your committee also supported a bill providing for the indexing of Land Records. In the form in which it was submitted it was mandatory and probably unworkable. After a conference with the Examiner of Public Records we suggested a modified bill which may do some good. This was passed in a form which puts the matter entirely in the hands of this state official, giving him some power to urge action by the Town Clerks.

Moved, seconded and adopted unanimously that the report of the Legislative Committee be accepted and placed on file.

The Chairman: Next is the report of the Advisory Committee in regard to the State Board of Health.

The Secretary: As Mr. Minor, Chairman of that Committee, is not present, I move that the matter be tabled and taken up later.

Motion seconded and carried without opposition.

The Secretary: The following applications have been received and printed in the announcement of this meeting and have been approved by the Board of Direction for active membership:

William M. Bolton, New Haven; Robert N. R. Chaffee, Meriden; Henry W. Geer, Middletown; John C. Glynn, New London; Bernard

Greenberg, New Haven; George E. Hamlin, Hartford; Cyrus P. Howes, New Haven; Clifford A. Peck, New London; Jeffrey O. Phelps, Simsbury; John P. Quay, New Britain; Caleb M. Saville, Hartford; Erwin W. Schrewe, Bridgeport; Harry T. Williams, Waterbury.

By vote they were declared elected to the respective classes of membership.

President Elwell then read his address. The address is printed on page 1

Mr. Kellogg: I move that a committee be appointed by the incoming President to take up the recommendations that the President has made in his report.

Motion seconded and carried unanimously.

Mr. Ferry: In the report of the Secretary and the report of the Board of Direction, and in the President's address, it is recommended that the dues of the Society be increased from $3 to $4 a year. In order to bring the matter before the Society for discussion I will present the following:

Resolved: That the Constitution be amended by increasing the dues from $3 to $4.

(Signed) C. A. Ferry,
C. J. Bennett,
W. R. Dunham, Jr.

President Elwell: This question is now open to discussion.

Discussion on Increasing Dues.

Mr. Kellogg: I believe I ought to give somebody a present for making that kind of a motion or recommendation. In 1901, in the President's Report, I stated that I thought it would be necessary to make such an amendment, in order to keep the Society up to a proper standard. Since that time we have been successful in getting advertisements, and that has kept us just about even. It is a rather frail foundation to stand on. I think the dues ought to be sufficient to pay our necessary expenses. By "necessary" expenses I mean those which are unavoidable, using the full meaning of that word. If we want to keep on doing the things we have been doing, we want to increase to $4 at least.

Mr. Bush urged the raising of dues from $3 to $4 per year, stating that for many years we had spent our money a little sooner than we had received it; and if we could accumulate a moderate surplus the Society could do many things for its members that it is afraid to start now.

Mr. Punderford: Don't think that the Society isn't paying its bills. It does pay its bills; but for a long term of years we have been closing our books as of a certain date and as of certain receipts up to date with a balance on the proper side of the ledger. The bills have been paid, as have this year's bills—some of them paid with next year's dues. This is not a large amount. We are not in bad shape. We don't want the Society to get that idea. We are not bankrupt or anything of that kind. Our credit is good, but we have been carrying over about fifty to a hundred and fifty dollars, varying in amount. It is not a deplorable condition at all, or a dangerous one; but there are things that the Society could do which would make for the benefit of the Society and for its members and for the standing of the Society, that the Board has not felt like recommending because the ready money was not in sight. That extra dollar would mean a great deal for the membership. It would put us on a good foundation. There is no desire to accumulate a great amount. We don't want three or four thousand dollars in the treasury, but we ought to have a few dollars instead of borrowing from next year all the time.

Mr. A. B. Hill: A number of years ago this Society had a research committee. We found ourselves very much hampered because we did not have any money to do the work that we greatly desired to do. I believe that committee made a report and recommended very strongly that the research committee be abolished or else that the dues be increased to $5. I believe the Society decided to abolish the research committee. It seems to me, as Mr. Punderford says, we don't want to be running behind. We ought to be able to increase the dues to at least $4. If we cannot get $4 worth out of the Society we better not have any.

Mr. Crandall: Mr. President, I heartily agree with what has been said by the gentlemen upon this subject, and I want to go one step further perhaps, by rehearsing the fact that two years ago this matter came before the Society, and it was voted that this change in the membership dues be brought to the summer meeting; and this was done. Unfortunately the Annual Report was not issued that year, until after the summer meeting; at least it was not in the hands of the members; so that a majority of the members did not understand the situation thoroughly, why the increase was desired. You realize that the attendance at these meetings is small in comparison with the total membership. The vote taken that summer showed a majority in favor of the change, but, as it takes two-thirds to carry an amendment to the constitution, we lost out by, I think, only three or four votes. Now, I think we need this $4; and I hope either that the report can be gotten into the hands of the members early enough to apprise them of the situation, before the summer meeting, or else when the letter ballot is sent out there can be something enclosed that will give the members the necessary information as to the reason why the change is advisable.

On motion of Mr. Bush, seconded by Mr. Burt, it was voted that a statement of reasons for increasing the dues be sent out with the letter ballot on same.

Mr. Ferry: I move that the amendment to the constitution, now in the hands of the Secretary, be submitted in the form of a letter ballot to be canvassed at the summer meeting.

Motion adopted unanimously.

THE CHAIRMAN: The election of officers for the ensuing year is the next business. The tellers will report. The tellers reported the canvass of the ballots for election of officers as follows:

President, Clarence Blakeslee, 107.
First Vice President, H. R. Buck, 104.
Second Vice President, Thomas A. Scott, 63.
Secretary and Treasurer, J. Frederick Jackson, 106.
Board of Direction, J. K. Punderford, 97.

These officers were declared by the President to be elected.

MR. BLAKESLEE: Mr. President and Fellow-members: I assure you that I appreciate more than I can express the honor you have conferred upon me. Had this office come two or three years ago, or before our present President's election, I think it would have been a great deal easier for me to fill it. President Elwell has set a very high standard for me to follow. It is said that when Admiral Farragut received his commission from the United States Government, it read, "The Government of the United States requires of you success." I feel that this Society requires of its president success, and with your coöperation, gentlemen, I purpose to give you a successful administration. This can never be done alone by me, but it can be done with your assistance. There are a number of things that President Elwell has inaugurated in the past year that I hope we will follow up, and perhaps improve. The meetings around the state have, I think, tended to promote good fellowship and interest in the Society. Certainly the number of applications for membership that we have had this year shows that. I can but repeat that with your coöperation I will do my best.

MR. BUSH: We ought to have a word from the new First Vice President.

MR. BUCK: I sincerely thank you for the honor you have done me in this election. I appreciate the chance to make return in a small measure, in the form of service, for some of the good times that others among you have given me while I have been a high private in the ranks. As far as the Vice President can, which is not very far, I assure you I will do my best for the Society.

Mr. Punderford made a plea for a full compliance with the request of the local committee to the members to return the applications for dinner tickets, and showed from his experience the difficulty in providing places for those attending on account of the indifference of some members in observing this formality.

THE PRESIDENT: Professor Lockwood of the Scientific School is here to make a statement. I am glad to give way to him.

PROFESSOR LOCKWOOD: Mr. Chairman: I presume this is in reference to the meeting planned by the local branch of the American Society of Mechanical Engineers for April 5, to which this Society is invited. I should prefer to leave the announcement to Professor Breckenridge, who will address you a little later, giving full details of the meeting.

Mr. Ferry offered the following resolution:

Moved, That the constitution be amended requiring that all amendments submitted to the Society be first approved at a regular business meeting before submitting them to a letter ballot.

(Signed) C. A. Ferry,
Henry R. Buck,
W. R. Dunham, Jr.,
Edward W. Bush,
J. K. Punderford,
C. J. Bennett,
A. B. Hill.

Mr. Buck: I move that it be submitted to a letter ballot to be canvassed at the summer meeting.

Motion seconded and carried unanimously.

Professor Breckenridge, introduced by President Elwell, spoke as follows: I would like to say a few words to the members of the Society. First, we are glad to have you meet in the Mason Laboratory, and hope you will have a pleasant, profitable meeting. Second, on the 5th of April next the New Haven section of the American Society of Mechanical Engineers has its Spring meeting. We are going to invite the civil engineers and the mining engineers and the electrical engineers to meet with us at that time, and we are going to make that meeting interesting to you. Particularly, I would call your attention to the address of the evening by Mr. Samuel Insull, President of the Commonwealth Edison Company of Chicago. His topic will be, "The Progress of Economic Power Generation and Distribution." Mr. Insull is an instructive and entertaining speaker, and we are planning a rather large meeting that night. That is the reason we are asking everybody to come to that meeting. There will be nothing else in the evening except his address. Those of you who are interested tell your friends, and don't forget the date—April 5th. In the afternoon there will be a program, and the secretary of this Society will communicate with your Secretary and endeavor to see that notice is mailed to those of you who are interested. We want to get together all the engineers in this vicinity, mechanical, civil, electrical and mining. We shall welcome you at this meeting.

The following committees on necrology were appointed by President Elwell:

For Professor Augustus J. DuBois—Professor John C. Tracy, Professor Samuel E. Barney, Professor Charles S. Farnham.

For Mr. J. K. Wilkes—Mr. Sheldon E. Minor, Mr. Charles H. Bunce, Mr. Theodore H. McKenzie.

The Secretary explained that the delay in sending out the notices for the meeting was due to difficulty in obtaining a speaker on the question of Preparedness and the Engineer. The notices were sent finally with this space blank. He also mentioned that the sending of the notices and ballots in the same enclosure was for the sake of economy.

Meeting adjourned till 2 p. m.

Afternoon Session, Tuesday, February 15th.

President Elwell: The speaker this afternoon is Colonel W. M. Black, of the United States Army. Colonel Black has done so many things that it would take nearly all afternoon to tell you even one half of them; but there are two very interesting things he has accomplished that I would call to your attention. The first was the cleaning up of Havana. You have all heard of that. Colonel Black was in charge of that work, which I can testify was done in a very thorough manner, as I visited Havana soon after the work was completed. Another fine job that he did was to raise the battleship *Maine*. He was the senior officer of the Board in charge of that work. Colonel Black is a very busy man; he had to tear himself away from very important work and I want him to know that we appreciate his coming. He will tell us what the engineers of Connecticut can do for their country in case of war.

The paper is printed on page 6.

Professor Winslow read his paper on "Recent Advances in the Improvement of Water Supplies."

Printed on page 17.

Kenneth Allen read his paper on "The Pollution of New York Harbor." Printed on page 28.

Session of Wednesday, February 16th.

Meeting called to order by President Elwell.

A paper on "Long Distance Telephony" was read by Mr. Everit.

Paper printed on page 64.

A paper on "Federal Valuation of Railroads" was read by Mr. Ripley.

Paper printed on page 49.

Professor Tracy made announcement that he could furnish members with a limited number of copies of the letter written by the late Professor DuBois.

"The Influence of the Street, as a Location, upon Street Railway Track Maintenance," was read by Mr. Cram.

Paper printed on page 136.

"Design of the New Stratford Avenue Bridge, Bridgeport," was read by Mr. Pagon.

Paper printed on page 127.

"The Proposed Thames River Railroad Bridge at New London," was read by Mr. Spencer.

Paper printed on page 120.

The Chairman: We will devote a few moments to business. To start with I want to say that I have a suggestion to make which I would like to incorporate in my annual report which I read yesterday. That is, that we hold, prior to the hour set for the dinner, a reception for the new officers and for those retiring. I believe that will give every member a chance to shake hands with the new officers. It is one of the functions of this society, you know, to get acquainted, and to create good fellowship among the members. Now, that was painfully lacking last night. I as president of the society mingled around among the people, over half of them strangers to me. Maybe it was largely my fault. At the same time I don't believe any one you can elect president can keep track of all the members. I believe what I have suggested would help largely in this respect, and I am going to make that suggestion to the incoming president in my report.

REPORT OF THE ADVISORY COMMITTEE RE STATE BOARD OF HEALTH, PRESENTED BY MR. MINOR.

Mr. Chas. C. Elwell, President, Conn. Society Civil Engineers, New Haven, Conn.:

DEAR SIR: The committee appointed by you at the summer meeting August 11, 1915, to coöperate and advise with the State Board of Health in preparing Rules and Regulations for guidance of engineers filing plans and reports on water works and sewerage systems, begs leave to report as follows:

The committee has conferred at New Haven, Waterbury and Hartford and has gone over this matter with great care. Mr. Jackson, engineer of the State Board of Health, has been present at all of our meetings after the first.

We found it necessary at the start to determine what was meant by the term "Water Supply" as used in these Acts. We considered the Board of Health to be entitled to a broad interpretation of its powers, but for the purpose of guiding us in drafting proposed rules we were unanimous in defining its jurisdiction as being limited to storage and character of the supply and its filtration or subsequent treatment. This covered the purity of the supply and safety of public health. We do not think Chapter 306 Public Acts of Connecticut 1915 concerning the pollution of water supply has anything whatever to do with the distribution system, or with pumping plants. Matters relating to public convenience as affected by a distribution system are at present cared for by the Utilities Commission.

The supervision of water companies seems divided into two parts. The first, relating to public health, belongs of necessity to the State Board of Health. The second, relating to service and rates, is at present handled by the Utilities Commission. However broad the jurisdiction of the Board of Health may eventually become we think at present it is interested only in the matter of public health. We, therefore, have only considered water supply in the former connection.

In drafting the outline herewith submitted we have confined ourselves to a general summary. Additional matter and further detail may be developed as occasion, or the experience of the Board demands. In many states, rules similar to these have been gone into with great detail. We think, however, it is much better to keep the requirements of the Board as simple as possible, leaving it to the engineer to amplify the information as each case requires. The number of applications which the Board will have to consider are relatively few, and each will have its own special problem. Rules covering all cases in detail would be too long. We feel justified, therefore, in making them as general as possible.

The following Rules and Regulations were recommended to the Board:

General Regulations of the State Board of Health of Connecticut to be Used for Submitting Data or Plans Covering Existing or Proposed Works Pursuant to Chapter 306 of the Public Acts of Connecticut 1915, Concerning the Pollution of Water Supplies, and Chapter 284 of Said Acts, Concerning the Disposal of Sewage in Inland and Tidal Waters.

Drawings, Documents and Samples:

To promote uniformity and to facilitate the handling and filing of drawings, documents, etc., the following provisions shall be observed:

1. *Dimensions of Drawings:*

   (a) The following standard outside dimensions are suggested; the first being the distance from top to bottom, and the second being the width.

   11 in. x 8½ in.
   22 in. x 30 in.
   25 in. x 38 in.
   22 in. x 70 in. (profiles only)

   The standard size of 22 in. x 30 in. shall be used, so far as practicable. Profiles and drawings larger than as above given will not be accepted.

   (b) Where the area of the municipality necessitates the preparation of drawings or profiles of greater dimensions than those above stated, the drawings or profiles shall be divided into equal sections of standard dimensions. Such sections shall be firmly bound together and numbered, and an index or key plan, supplied, indicating the area covered by, or contents of, each sheet.

   (c) All drawings submitted under the same application shall, as far as possible, be of equal dimensions, and shall be firmly bound together at the left side; a margin being left for this purpose.

2. *Character of Drawings:*

   Drawings submitted shall be white paper, or cloth prints of the best quality.

3. *Title on Drawings:*

   Each drawing submitted shall have printed at the right hand bottom corner, the name of the municipality or corporation owning said works, or for which the proposed works are to be constructed, and such title as may be necessary to explain the drawing together with date and signature of the engineer under whose supervision the works are designed

(4) *Symbols on Drawings:*

Letters and figures shall be clearly and distinctly made. Where plans cover extension of existing works present mains shall be shown by full lines, and proposed mains by broken lines. Topography where shown shall conform to the symbols used by the United States Geological Survey. A legend shall appear on each map explaining symbols used.

(5) *Separate Drawings for Water Works and Sewers:*

Separate drawings shall be submitted for water works, sewerage systems and disposal works.

(6) *Specifications and Reports:*

(a) Specifications and reports shall be typewritten or printed; the sheets being firmly bound together.

(b) They shall have such title as may be necessary to explain the specifications and reports together with data and signature of the engineer under whose supervision they are drawn.

(c) Where the specifications for the work under the application are exactly similar to those previously submitted and approved, it will be sufficient if a statement is made to that effect, provided the date on which said specifications were submitted is recited.

(7) *Samples for Analysis:*

Samples of water or sewage to be analyzed shall be taken in accordance with instructions issued by the State Board of Health and sent to the Director of the State Laboratory, or other analyst approved of by said Board.

(8) *Alterations:*

No modifications of any plan, or design approved of by the State Board of Health shall be made without the written consent of the Board.

PROPOSED SYSTEM OF WATER SUPPLY:

(1) *Application for Approval:*

Written application shall be made to the State Board of Health by any municipality, corporation or individual constructing a water supply, or purification works, for its approval of said work.

(2) *Description of Work:*

A report shall be submitted by said applicant through its engineer, giving a description of said work and such data as may be necessary to a clear understanding of its character and efficiency. Information shall be given for this purpose as follows:

(a) Estimated population and rate of increase, based upon census and other available data.

(b) Present consumption and rate of increase with estimated supply available from proposed work.
(c) Sources of supply to be used, location, extent and character of watershed, with maps showing corporate limits and complete detail maps and specifications of proposed works.
(d) Chemical and bacteriological examinations sufficient to show quality of supply.
(e) Present source of pollution, if any.
(f) Particulars as to any provision made for turning water other than public supply into mains for fire or other purposes.

(3) *Treatment of Supply:*

(a) Method of treatment. Sedimentation, filtration, sterilization, type of filter, nature of filtering media.
(b) Details of operation. Automatic measurement of flow. Nature and amount of coagulent and disinfectant. Bypasses. Method of cleaning.
(c) Results obtained. Reports and records. Reserve areas for future extensions.

PROPOSED SEWERAGE SYSTEM:

(1) *Filing of Plans:*

Any person, corporation or municipality constructing a sewerage system shall file with the State Board of Health plans and specifications of said system before starting its construction.

(2) *Description of Work:*

A report shall be submitted by said party through its engineer, giving a description of said work, and such data as may be necessary to enable the Board to form an opinion of its character and efficiency. Information shall be given for this purpose as follows:

(a) Map showing area and topography of proposed system and corporate limits.
(b) Estimated present population and rate of increase based upon census and other available data.
(c) Estimated water consumption within said area.
(d) General character of subsoil.
(e) Complete detailed description of proposed works, outlets, overflows, etc., with drawings and specifications thereof.
(f) Where combined sanitary and storm water sewers are proposed, data and assumption relating to run-off and formula on which size of sewers are based, together with maximum flow.
(g) Data relating to rainfall, particularly with reference to short periods of heavy precipitation.

(h) Nature of ground surface, areas paved and extent of buildings.
(i) Estimated normal and maximum rate of flow expressed in gallons per twenty-four hours.
(j) Final disposal of effluent in relation to stream flow and pollution. Description of further use made of stream.

PROPOSED SYSTEM OF SEWAGE OR REFUSE TREATMENT:

(1) *Filing of Plans:*

Any person, corporation or municipality constructing a sewage or refuse treatment system shall file with the State Board of Health drawings and specifications of said system before starting its construction.

(2) *Description of Work:*

A report shall be submitted by said party through its engineer, giving a description of said work, and such data as may be necessary to a clear understanding of its character and efficiency. Information shall be given for this purpose as follows:

Sewage:

(a) Estimated maximum and normal amount of sewage and amount per capita to be treated expressed in gallons per twenty-four hours.
(b) Character of sewage in reference to domestic, manufacturing and trade wastes.
(c) Processes involved with detailed description of works.
(d) Operation and maintenance. Devices for automatic control and measurement.
(e) Character and disposal of effluent particularly in reference to discharge into streams or water courses and their subsequent use.
(f) Disposal of sludge.
(g) Bypasses, if any, and purpose for which constructed.

Refuse:

(a) Method or processes to be used.
(b) Type of apparatus and capacity.
(c) Control and operation.
(d) Location in reference to other buildings, water courses and highways.
(e) Disposal of waste.

We wish to express to Mr. Jackson as engineer of the State Board of Health, our appreciation of his courtesy in extending to us an invitation to meet and advise with him on these general regulations, and to assure him of the coöperation of each member of the Society in his work as Engineer of the State Board of Health.

EDWARD E. MINOR,
CHARLES E. CHANDLER,
CALEB MILLS SAVILLE,
ROBERT A. CAIRNS,
SHELDON E. MINOR,
Committee.

NEW HAVEN, CONN., December 29, 1915

(Moved, seconded and carried unanimously that the report of the advisory committee be accepted and placed on file, and that the committee be discharged.)

THE SECRETARY: In relation to this I have the following letter from the State Board of Health:

February 15, 1916.

Mr. Charles C. Elwell, President, Connecticut Society of Civil Engineers, New Haven, Conn.

DEAR SIR:—The State Board of Health at its regular meeting held February 3d, 1916, voted to extend to the Connecticut Society of Civil Engineers, through you, its appreciation of the valuable assistance rendered in submitting rules and regulations covering water pollution and sewage disposal.

Very truly yours,
J. T. BLACK, M.D.,
Secretary.

Mr. Verrill and Mr. Nord not being present on account of illness, Mr. Verrill's paper was read by Mr. Snell. Paper presented by Mr. Nord was read by title only. Papers printed on pages 77, 95.

THE CHAIRMAN: If there is no further business it is the time to introduce the new president. Mr. Blakeslee will please come forward and assume the duties of this office.

MR. BLAKESLEE: Mr. Ex-President and members of the Connecticut Society of Civil Engineers: For a good many years I have been a private in the ranks of the Society; and if my own wishes had been consulted I would still be a private. But you have decided to elevate me to this position, and I surely would be devoid of sentiment if I did not appreciate this honor. I must say, however, that it seems to me you have taken a great chance in electing a contractor for your president, and a contractor for your second vice president. How do you know but what we will get together and change the specifications so that we may have things a little more as we want them? I feel that the contractor and the engineer should be closer together. I attended a dinner in New York a few weeks ago of an association called the "General Contractors' Association of New York City." There were 900 at that dinner, and 665, I think it was, were engineers. Why, gentlemen, when I was a young fellow it would have been a crime for any number of engineers to have supped or broken bread with contractors. It was a crime, but to-day, whether the engineer has subserved his conscience to his stomach I don't know, but he certainly will eat now whenever you ask him. In all seriousness, doesn't it seem to you that the feeling is a great deal better than it used to be, when there was so much suspicion on both sides? The contractor thought all the time that the engineer was trying to get the better of him, and, of course, vice versa. Now, to-day, in any large contracting concern, the principal member is an engineer. I recall a few years ago, when I was an engineer, as I think I am an engineer to-day, but when I followed it more particularly than I do now, that we had a contract running up to about a million dollars. And I talked with the contractor as to the plant he was to put on that work and the method to be pursued in doing it. He had no idea of what he was to put on. Now you all know that to-day when a man takes a contract one of the principal things is to have the engineer take the plan that the designing engineer has given him, go through it carefully, and see what is the best sort of equipment and the best method; and to have some sort of a plan. So that the engineer has come into his own. He is an important factor indeed in the big work to-day, a bigger man than he used to be.

Nowadays they put experienced engineers on public corporations. They have taken the places formerly held by laymen. The public corporations have awakened to the fact that the engineer is the man to get things done; and if my election to this office results in nothing else than a better feeling between the engineer and the contractor I shall feel that the year has not been wasted. And I want to say, gentlemen, in passing, that you have given me a hard task.

Votes of thanks were extended to the Sheffield Scientific School for the use of the hall, and to Col. Black, Professor Winslow and Messrs. Allen, Ripley and Pagon for the presentation of their papers.

The meeting was then adjourned.

CONSTITUTION.

ARTICLE I.

NAME AND OBJECT.

SECTION 1.—The name of this Society shall be the CONNECTICUT SOCIETY OF CIVIL ENGINEERS.

OBJECT.

SEC. 2.—The object of this Society shall be the professional improvement of its members; the encouragement of social intercourse among men of practical science, and the advancement of engineering in its several branches, to wit: Civil, hydraulic, naval, sanitary, mechanical, electrical, architectural, mining, geological, metallurgical, and chemical; the reading and discussion of papers, or to hear lectures on any of the above topics relating to engineering science, and the transaction of all business properly belonging to said Society.

ARTICLE II.

MEMBERSHIP.

SECTION 1.—The membership of this Society shall consist of Members, Honorary Members and Associate Members.

MEMBERS.

SEC. 2.—Members must be at least twenty-one years of age and have had two years' actual experience in some branch of engineering or surveying, or shall have been graduated from an engineering course in a college or university of recognized standing, and they only shall be entitled to vote or transact business for the Society.

HONORARY MEMBERS.

SEC. 3.—Honorary Members may be as many as the Society shall elect. They shall have no vote, nor shall they be eligible to hold office. They shall have the right to attend all public meetings and to enjoy such other privileges as the Society may see fit to grant, excepting, however, such Honorary Members as may be elected from *active membership*, when they shall retain their right to vote and to hold office.

ASSOCIATE MEMBERS.

SEC. 4.—Any person desiring to become associated with this Society, who is not eligible to active membership, may make application, and if said application receives a favorable report from the Board of Direction, it shall be acted upon by the Society at the next regular meeting, and if said candidate shall receive a majority of the votes cast he shall be declared elected as an Associate Member. Associate Members shall have no vote, nor shall they be eligible for any office.

ARTICLE III.

OFFICERS AND THEIR DUTIES.

OFFICERS.

SECTION I.—The officers of the Society shall be, a President, two Vice Presidents, a Secretary and Treasurer, an Assistant Secretary, and four Directors, one of whom shall be the last living Ex-President.

ELECTION OF OFFICERS.

SEC. 2.—The officers, excepting the Assistant Secretary and the Director who is the last living Ex-President, shall be elected at the annual meeting, and shall hold their respective offices until the final adjournment of the meeting in which others are elected and qualified in their places.

PRESIDENT.

SEC. 3.—The President shall preside at all meetings when present. He shall be chairman of the Board of Direction, and of all standing committees, and shall appoint all special committees, unless otherwise ordered by a vote of the Society.

VICE PRESIDENTS.

SEC. 4.—In the absence or inability of the President to act, the Senior Vice President present shall perform his duties.

SECRETARY.

SEC. 5.—The Secretary shall attend all meetings of the Society, and the Board of Direction, and shall keep the minutes thereof. He shall conduct the general correspondence of the Society, receive communications addressed thereto, and present the same to the proper committees, officers, or meetings. He shall issue notices of all meetings, inform committees of their appointment, and officers and new members of their election. He shall notify all committees of coming meetings and prepare the matters for presentation. He shall keep a complete list of all members, with their addresses and dates of election. He shall publish the annual report. He shall perform such other duties pertaining to his office as may be imposed upon him by the Society or by the Board of Direction, and shall receive a salary to be fixed by the Society.

TREASURER.

SEC. 6.—The Treasurer shall keep the accounts, collect all the funds of the Society and shall deposit the same to the credit of the Society in such depository as may be designated by the Board of Direction. He shall pay all bills, when approved by the President or a majority of the Board of Direction. He shall keep book accounts of his receipts and expenditures, which shall at all times be open to the inspection of the Board. He shall make a duly audited itemized report to the annual meeting. He shall give bonds for the faithful performance of his duties, in such amounts and with such sureties as the Board of Direction may require, and he shall receive such remuneration as the Society may vote to him from time to time. The Board of Direction shall audit the Treasurer's accounts and books annually.

ASSISTANT SECRETARY.

SEC. 7.—The Assistant Secretary shall be appointed annually by the President, and his duties shall be such as would pertain to the office of executive secretary.

BOARD OF DIRECTION.

SEC. 8.—This Board shall consist of the President, the two Vice Presidents, and the four Directors. It shall have supervision and care of all the affairs of the Society and shall conduct the same in accordance with the Constitution and By-Laws. The President or one of the Vice Presidents shall preside at all meetings of the Board in the order of seniority. In the absence of all these officers a chairman *pro tem.* may be appointed for the meeting. At the annual meeting in February, 1916, only one Director shall be elected, to serve for one year. At the annual meeting in February, 1917, three directors shall be elected, one to serve for one year, one to serve for two years, and one to serve for three years; and at each subsequent annual meeting one director shall be elected to serve for three years. A Director elected at and after the annual meeting in 1917 shall not be eligible for reëlection to any office until one year after his term of office has expired. At the annual meeting in 1917, the person receiving the highest number of votes shall be the director for three years, the one receiving the next highest number of votes, the director for two years, and the one receiving the next highest number, the director for one year. In case of a tie vote, the terms of office shall be decided by lot. Four members shall constitute a quorum to transact business.

ARTICLE IV.

ELECTIONS.

OFFICERS, WHEN ELECTED.

SECTION 1.—At each annual meeting the Society shall elect by ballot, a President, two Vice Presidents, a Secretary and a Treasurer, to serve one year. At the annual meeting in 1916, a Director shall be elected to serve one year; at the annual meeting in 1917 three Directors shall be elected, one to serve one year, one to serve two years and one to serve three years. At each annual meeting after 1917 one Director shall be elected to serve three years.

NOMINATIONS, HOW MADE.

SEC. 2.—A nominating blank, containing a list of officers to be voted for, shall be sent by the Secretary to each member, at least sixty (60) days before the day of the annual meeting. The nominations for officers shall be returned to the Secretary in an envelope endorsed with the member's signature, within twenty-one (21) days from the date upon which the blanks were mailed to members, and shall be delivered by him, unopened, to the Board of Direction at a meeting to be held by them to canvass such nominations.

A member nominated for an office by as many as ten (10) other members may become a candidate for that office. If a member be nominated for more than one office, he shall be considered as having been nominated for that office for which he received the most nominating ballots.

If no member receives ten (10) nominating ballots for an office, or if for any reason there should be no candidate for an office, the Board of Direction shall nominate at least two candidates for that office.

All nominees for office shall be notified at once by the Secretary of their nomination and, unless the Secretary receives a prompt declination, it shall be assumed that they have accepted such nomination.

ELECTIONS, HOW CONDUCTED.

SEC. 3.—At least twenty-one (21) days before the annual meeting the Secretary shall send each member a ballot, containing the names (arranged alphabetically) of the candidates for each office. This shall be accompanied by an envelope addressed to the Secretary, with a blank space on the back for the signature of the member voting, also a blank envelope carrying no mark for recognition.

Each member shall signify his choice of candidates on the ballot and return it to the Secretary in two sealed envelopes; the inner one to be left entirely blank, and the outer one endorsed with signature of sender.

Ballots may be sent by mail to the Secretary or handed to him directly. The Secretary shall deliver the ballots, unopened, to the tellers appointed by the presiding officer.

The polls will close at eleven o'clock in the morning of the day of the regular annual business meeting of the Society.

MEMBERS IN ARREARS CANNOT VOTE.

SEC. 4.—It shall be the duty of the Treasurer to furnish the tellers with an alphabetical list of members in arrears for dues for two years or more, and no vote from a member so in arrears shall be counted. Ballots received from such members shall be returned to them unopened with a statement of the reason for such action.

PLURALITY ELECTS.

SEC. 5.—The candidate for each office receiving a plurality of the votes shall be declared elected. In case of a tie vote, the meeting shall proceed to vote by ballot for the candidates who are tied.

NOTIFICATION.

SEC. 6.—The Secretary shall officially notify in writing each officer of his election.

Officers so elected shall qualify and assume their duties immediately after the adjournment of the meeting at which they are elected, and shall hold office until their successors are duly elected and qualified.

VACANCIES.

SEC. 7.—Vacancies occurring for any cause in the list of officers shall be filled by the Board of Direction.

ELECTION OF MEMBERS.

SEC. 8.—Each application shall be announced on the notices for the next meeting after it is received, shall then be considered by the Board of Direction, and, if approved, shall be presented to the Society for ballot at a regular meeting. If a candidate receives a majority of the ballots, he shall be declared elected. In case of rejection, no minute shall be published, but the Secretary shall notify the applicant by letter.

APPLICATION FOR MEMBERSHIP.

SEC. 9.—All applications for membership or for transfer from one grade of membership to another, shall be made on a regular form, to be secured from the Secretary, and to be endorsed by three Members. This form shall contain, immediately over the signature of the applicant, a clause in which the applicant shall agree that if elected he will be governed in all Society matters by the Constitution and By-Laws, and will forward the interests of the Society at all times.

ARTICLE V.

MEETINGS.

ANNUAL MEETINGS.

SECTION 1.—There shall be a *regular annual meeting* held on the third Tuesday of February of each year, at such place as may be selected by the Board of Direction, of which due notice shall be given by the Secretary.

MEETINGS, HOW CALLED.

SEC. 2.—Special meetings may be called by the President and, when so called, notice of the meeting specifying the business thereof shall be mailed by the Secretary to the postoffice address of each member at least ten days before such meeting shall be held. Special meetings shall be called by the President on written application of any ten (10) members.

QUORUM.

SEC. 3.—Ten per cent. of the membership shall constitute a quorum for the transaction of ordinary business, except for the election of officers or for voting on amendments to the Constitution or By-Laws, which shall require fifteen per cent.

ARTICLE VI.

DUES.

SECTION 1.—The annual dues of Members and Associate Members shall be three ($3.00) dollars per year, payable in advance at the annual meeting.

Members elected at any time of the year shall pay full dues for that year.

SEC. 2.—Honorary Members shall pay no annual dues.

SEC. 3.—The Board of Direction shall have power to remit dues when, in their opinion, it is for the best interest of the Society.

ARTICLE VII.

DEPRIVATION OF MEMBERSHIP.

SECTION 1.—Any member whose dues shall remain unpaid for two (2) years shall be notified by the Treasurer, by sending by registered mail a bill for dues in arrears, on the face of which bill shall be printed the sections of the Constitution covering such cases. If the dues are not paid within thirty (30) days after such notification, the matter shall be presented to the Board of Direction, who shall have power to drop such member from the roll.

RESIGNATIONS.

SEC. 2.—Resignations must be submitted in writing to the Secretary, and may be accepted by the Board of Direction when all indebtedness to the Society has been discharged.

SEC. 3.—All charges against any member shall be investigated by the Board of Direction before being submitted to the Society.

Any member may be expelled for conduct which may be deemed prejudicial to the Society, by a two-thirds vote of the Members present at a business meeting; provided, that not less than fifteen (15) vote for expulsion, and that such member shall have had one month's notice of the charges preferred against him and of the time appointed for their consideration. All charges must fully set forth the offense or offenses alleged, and must be signed by the members preferring them. An attested copy must be furnished the accused, who shall be entitled to be present and to be heard in defense, in person or by attorney, at all meetings at which the charges are investigated, except during the time when a final vote is being taken.

ARTICLE VIII.

AMENDMENTS TO THE CONSTITUTION.

SECTION 1.—Proposed amendments to this Constitution must be presented in writing at a regular business meeting of the Society, and signed by at least three Members.

Amendments so presented shall be read at the meeting and a copy filed with the Secretary at the same time. At the meeting when presented the proposed amendments may be discussed and amended, but cannot be adopted.

SEC. 2.—At any regular business meeting the amendments previously proposed, according to Section 1, may be voted upon by letter ballot. These ballots shall be sent out with the call for the meeting and shall have the proposed amendment, together with the section of the present Constitution covering the point in question, printed upon the ballot. With the ballot shall also be sent an envelope directed to the Secretary and marked "Ballot on Amendment." The Secretary shall keep these letters unopened and present to the presiding officer all replies received up to the hour of closing the polls. Tellers shall be appointed by the presiding officer, who shall open and count all ballots. The result shall be announced at the meeting by the presiding officer. Two-thirds of the ballots cast will be necessary for the adoption of an amendment.

Sec. 3.—The Board of Direction is authorized to number the Articles and Sections of the Constitution and By-Laws to correspond with any changes that may be made.

BY-LAWS.

MEETINGS.

1. In addition to the regular annual meeting, as provided by the Constitution, the Society shall hold at least one other general meeting, and may hold such other meetings to listen to lectures or addresses, or to visit engineering works of interest, or of a purely social nature, as the Board of Direction may decide to call.

GENERAL ORDER OF BUSINESS AT ANNUAL MEETING.

2. The following general order of business shall be observed at annual meetings:

1. Presentation of, and action upon, minutes of last meeting.
2. Report of Board of Direction.
3. Report of Secretary.
4. Report of Treasurer.
5. Report of any Special Committees.
6. Election of new members.
7. Election of officers.
8. Address of President.
9. Miscellaneous business.
10. Papers, lectures or addresses.
11. Adjournment.

BUSINESS MEETINGS—ORDER.

3. The following general order shall be observed at Business Meetings:

1. Presentation of, and action upon, minutes of last meeting.
2. Miscellaneous announcements.
3. Stated business.
4. Adjournment.

4. Contributing Members under the old Constitution shall become Associate Members upon the adoption of the Revised Constitution.

5. Actual personal transportation expenses incurred by the Secretary in attending meetings shall be paid from the Society treasury, upon approval of the President or two members of the Board of Direction.

6. In the election of Honorary Members, a unanimous vote is necessary to elect.

7. The Society may at any time, duly named for the purpose, enact By-Laws for the future guidance, consonant with the Constitution. These By-Laws may be amended or repealed at any meeting, in the call for which meeting a copy of the proposed amendment or addition shall have been printed and sent to each member with the said notice.

PARLIAMENTARY RULES.

8. In all questions arising at any meeting, involving parliamentary rules, not provided for in these By-Laws, Roberts' Rules of Order shall be the governing authority.

VISITORS.

9. Visitors may be admitted to meetings under such rules as the meeting may prescribe.

10. All forms, such as blanks for application for membership, ballots for officers, ballots on amendments to Constitution or By-Laws, and other necessary blanks for the conduct of the business of the Society, shall be prepared by the Secretary and approved by the Board of Direction.

CHARTER MEMBERS OF THE SOCIETY.

HONORARY

Prof. John E. Clark	April, 1884
George H. Frost	April, 1884

ACTIVE

E. P. Augur	April, 1884
C. H. Bunce	April, 1884
L. W. Burt	Jan. 13, 1885
C. E. Chandler	April, 1884
R. S. Hulbert	April, 1884
C. M. Jarvis	April, 1884
H. J. Kellogg	April, 1884
F. W. Laforge	Jan. 13, 1885
W. B. Palmer	Jan. 13, 1885
S. C. Pierson	Jan. 13, 1885
A. W. Rice	April, 1884
William G. Smith	April, 1884
Nelson J. Welton	April, 1884

List of Members.

With Addresses and Dates of Election.

Members are particularly requested to inform the Secretary at once of any change in address.

HONORARY MEMBERS.

BRECKENRIDGE, LESTER P. .... Feb. 9, 1914
Director Mason Laboratory, Yale University, New Haven, Conn.

CHITTENDEN, PROF. RUSSELL H. .... April 20, 1901
Dean of Sheffield Scientific School of Yale University, New Haven, Conn.

CLARK, JOHN E. .... April, 1884
Prof. Mathematics, Emeritus, at Sheffield Scientific School, Yale University,
Springfield, Mass.

FITZGERALD, DESMOND .... Jan. 8, 1901
Consulting Engineer, Brookline, Mass.

FROST, GEORGE H. .... April, 1884
President Engineering News Publishing Co., New York.

FULLER, WILLIAM B. .... Feb. 12, 1908
Consulting Engineer, 150 Nassau St., New York.

HADLEY, DR. ARTHUR T. .... April 20, 1901
President Yale University, New Haven, Conn.

HAUPT, LEWIS M. .... Feb. 12, 1907
Consulting Engineer, Cynwyd, Pa.

HAYNES, EDWARD C. .... Jan. 14, 1890
744 E. 6th St., Erie, Pa.

LUTHER, FLAVEL S., JR., ... Feb. 9, 1904
President Trinity College, Hartford, Conn.

PETTEE, WILLIAM E. .... Jan. 10, 1899
Civil Engineer, Salisbury, Conn.

SCOFIELD, HORACE G. .... Feb. 14, 1906
Civil Engineer, Bridgeport, Conn.

SKINNER, FRANK W. .... Jan. 9, 1900
Editorial Staff of the Engineering Record, New York.

MEMBERS.

ALDERSON, ALGERNON B. .... Jan. 10, 1899
Civil Engineer, Hartford, Conn.

ALLEN, GEORGE B. .... Aug. 12, 1908
Mill Architect and Civil Engineer, Hartford, Conn.

AMRHYN, GUSTAVE X., Associate Member .... Feb. 9, 1904
Superintendent of Parks, New Haven, Conn.

ANDREWS, RALPH J. ....Feb. 11, 1913
Civil Engineer, New Haven, Conn.

ATWOOD, THOMAS C. ....Feb. 15, 1916
Civil Engineer, New Haven, Conn.

AUGUR, EDWIN P. ....April, 1884
Civil Engineer, Middletown, Conn.

AYMEN, NATHAN ....Feb. 14, 1912
Civil Engineer, New Haven, Conn.

AZHDERIAN, REUBEN B. ....Feb. 12, 1907
Civil Engineer, Newark, N. J.

BACKES, WILLIAM J. ....Feb. 8, 1910
Engineer, Maintenance of Way, N. Y., N. H. & H. R. R., New Haven, Conn.

BACON, ARTHUR W. ....Feb. 9, 1914
Hall & Bacon, Civil Engineers, New Britain, Conn.

BALDWIN, GEORGE [illegible] ....[illegible]
Civil Engineer, New Haven, Conn.

BANTA, D. SCHUYLER ....Aug. 23, 1905
Civil Engineer, New Haven, Conn.

BARKER, GEORGE P. ....[illegible]
Civil Engineer, Meriden, Conn.

BARKER, WILLIAM H. ....Aug. 10, 1904
Expert in Patent Causes, 160 Broadway, New York.

BARNES, NIAR ....[illegible]
Superintendent of Streets, New Haven, Conn.

BARNEY, SAMUEL E. ....Jan. 9, 1900
Asst. Prof. Civil Engineering, Sheffield Scientific School, Yale University,
New Haven, Conn.

BARRY, W. VINCENT ....Feb. 11, 1913
Civil Engineer, New Haven, Conn.

BARTLETT, FRANK ....Aug. 17, [illegible]
Civil Engineer, Torrington, Conn.

BEACH, CHARLES EDWARD ....Jan. 10, 1893
Beach & Co., Civil Engineers, Hartford, Conn.

BEARD, THEODORE W. ....Feb. 10, 1914
Civil Engineer, Shelton, Conn.

BEARDSLEY, ROBERT D. ....Aug. 17, 1909
Civil Engineer, Naugatuck, Conn.

BELDEN, EDGAR T. ....Jan. 8, 1901
Box 931, Pittsfield, Mass.

BENNETT, CHAS. J. ....Aug. 14, 1906
State Highway Commissioner, Hartford, Conn.

BERNHARD, WILLIAM E. ....Feb. 15, 1916
Civil Engineer, Bridgeport, Conn.

[illegible] ....[illegible]
Civil Engineer, Groton, Conn.

BISHOP, CARLTON T. ....Aug. 13, 1913
Asst. Prof. Structural Engineering, Sheffield Scientific School, Yale University,
New Haven, Conn.

BLACK, WILLIS J. ....Feb. 13, 1906
Civil Engineer, Stratford, Conn.

BLAIR, CLARENCE M. ....Aug. 10, 1904
Civil Engineer, New Haven, Conn.

BLAKESLEE, CLARENCE	Jan. 9, 1900	Civil Engineer and Contractor, New Haven, Conn.
BLAKESLEE, HAROLD L.	Feb. 11, 1913	Blakeslee & Sons, New Haven, Conn.
BLATCHLEY, WILLIAM J.	Aug. 10, 1904	Civil Engineer, New Haven, Conn.
BOLTON, WILLIAM M.	Aug. 12, 1915	Civil Engineer, New Haven, Conn.
BOWEN, JOHN F.	Feb. 14, 1911	Civil Engineer, South Manchester, Conn.
BOYLAN, JAMES E.	Feb. 14, 1912	Berlin Construction Co., Berlin, Conn.
BRADLEY, DANIEL E.	Jan. 9, 1894	President Berlin Construction Co., Berlin, Conn.
BRADLEY, EDWARD F.	Feb. 9, 1915	Civil Engineer, Waterbury, Conn.
BREMER, J. REUBEN	Feb. 14, 1912	Civil Engineer, New Haven, Conn.
BRETT, THOMAS C.	Aug. 10, 1904	Secretary Yale Safe & Iron Works, West Haven, Conn.
BREWER, WILLARD SEYMOUR	Feb. 12, 1907	City Engineer's Office, Hartford, Conn.
BRINSMADE, DANIEL E.	April 20, 1901	Secretary and Assistant Engineer Ousatonic Water Co., Shelton, Conn.
BRISTOL, WARREN P.	Aug. 12, 1908	Associate Member, Hartford, Conn.
BROWN, CHARLES B.	Aug. 14, 1907	Prof. of Railroad Engineering, University of Maine, Orono, Maine.
BROWN, CHARLES O.	Jan. 11, 1898	City Engineer, Danbury, Conn.
BROWN, RAYMOND J.	Feb. 15, 1916	Civil Engineer, Bridgeport, Conn.
BUCK, HENRY R.	Jan. 10, 1899	Ford, Buck, & Sheldon, Civil Engineers, Hartford, Conn.
BUNCE, CHARLES H.	April, 1884	Civil Engineer, Hartford, Conn.
BURGESS, HAROLD T.	Feb. 15, 1916	Civil Engineer, Meriden, Conn.
BURGHARDT, WALLACE	Feb. 13, 1906	Town Engineer, North Canaan, Conn.
BURNS, WILLIAM H.	Feb. 15, 1916	Civil Engineer, Gales Ferry, Conn.
BURT, LUTHER HAROLD	Aug. 14, 1900	Civil Engineer and Surveyor, Hartford, Conn.
BURT, LUTHER W.	Jan. 13, 1885	L. W. Burt & Son, Active and Consulting Civil Engineers, Hartford, Conn.
BUSCHOR, EMIL CHARLES	Jan. 10, 1899	Civil Engineer and Surveyor, 324 E. 2d Ave., Roselle, N. J.
BUSH, EDWARD W.	Jan. 10, 1899	Member State Board of Engineers having supervision over Dams and Reservoirs, Hartford, Conn.
BUSHNELL, W. G., Associate Member	Feb. 14, 1905	Electrical Engineer, New Haven, Conn.

CADWELL, WILLIAM H. ....May 31, 1893
Civil Engineer, New Britain, Conn.

CAHN, ALEXANDER ....Jan. 9, 1900
Civil Engineer, New Haven, Conn.

CAIRNS, ROBERT A. ....Aug. 29, 1890
Sanitary and Hydraulic Engineer and City Engineer, Waterbury, Conn.

CAMPBELL, CARROL A. ....Feb. 9, 1909
Civil Engineer, Middletown, Conn.

CARLISLE, HARRY E. ....Jan. 9, 1900
Conduit Engineer, S. N. E. Telephone Co., New Haven, Conn.

CARROLL, CHARLES D. ....Feb. 14, 1911
Civil Engineer, New London, Conn.

CHAFFEE, ROBERT N. R. ....Aug. 15, 1916
Civil Engineer, Meriden, Conn.

CHAMBERLIN, CYRUS C., Associate Member ....Feb. 15, 1916
Civil Engineer, Plantsville, Conn.

CHANDLER, CHARLES E. ....April, 1884
Chandler & Palmer, Norwich, Conn.

CHAPMAN, C. H., Associate Member ....Feb. 15, 1916
Civil Engineer, Bridgeport, Conn.

CHASE, CHARLES F. ....March 30, 1900
Engineer Berlin Construction Co., New Britain, Conn.

CHENEY, RICHARD OTIS, JR. ....Jan. 9, 1900
Civil Engineer, South Manchester, Conn.

CLARK, HERBERT G. ....July 18, 1899
Engineer of Keney Park, Hartford, Conn.

CLARK, ROSCOE N. ....July 18, 1899
City Engineer, Hartford, Conn.

CLARK, VINCENT B. ....Feb. 9, 1904
City Engineer, Ansonia, Conn.

CLARK, WILLIAM S. ....July 14, 1890
Civil Engineer, Meriden, Conn.

CLARKE, STANLEY N. ....Aug. 16, 1911
Civil Engineer, Milford, Conn.

CLARKE, WALDO E. ....Feb. 10, 1914
Civil Engineer, New London, Conn.

CODAIRE, ALFRED H. ....Feb. 15, 1916
Civil Engineer, New Haven, Conn.

COE, FREDERICK L. ....Feb. 14, 1911
Civil Engineer, New Haven, Conn.

COE, THEODORE I. ....Jan. 9, 1900
Architect, Room 1100, Municipal Bldg., New York.

COGGESHALL, R. C. P. ....June, 1887
Superintendent of Water Works, New Bedford, Mass.

COLGAN, ALFRED P. ....Feb. 9, 1915
Civil Engineer, Waterbury, Conn.

COLGAN, WILLIAM R. ....Feb. 9, 1915
Civil Engineer, Waterbury, Conn.

COLLINS, EDWARD T. ....Feb. 11, 1913
U. S. Geological Survey, New London, Conn.

COLLINS, HARRY C. ....July 18, 1899
Contracting Engineer, Berlin Construction Co., Springfield, Mass.

COMSTOCK, LEWIS B. ... Aug. 10, 1904
Civil Engineer, Comstock Block, East Hartford, Conn.

CONE, JOSEPH W. ... Aug. 12, 1908
Civil Engineer, Greenwich, Conn.

CONNOR, M. C. ... Feb. 14, 1911
Civil Engineer, Hartford, Conn.

CRAM, ROY C. ... Feb. 8, 1910
Assistant Engineer, Brooklyn Rapid Transit Co., Brooklyn, N. Y.

CRANDALL, GEORGE K. ... Jan. 11, 1887
City Engineer, New London, Conn.

CRAWLEY, ERNEST W. ... Feb. 14, 1912
Civil Engineer, New Haven, Conn.

CROSS, ROBERT ALLIS ... Feb. 15, 1916
Civil Engineer, Hartford, Conn.

CURTIS, ABNER L. ... Feb. 14, 1912
Civil Engineer, Pawtucket, R. I.

CURTIS, CHARLES D. ... Aug. 17, 1909
Civil Engineer, Naugatuck, Conn.

CURTIS, FAYETTE S. ... Jan. 9, 1900
Vice President N. Y., N. H. & H. R. R., Boston, Mass.

CURTIS, GEORGE H. ... Aug. 17, 1909
Treasurer O'Brien Construction Co., New York City.

DABOLL, ERNEST C. ... Feb. 14, 1911
Civil Engineer, Groton, Conn.

DABOLL, LOREN E. ... Jan. 8, 1895
Civil Engineer, New London, Conn.

DARROW, COURTLAND R. ... Jan. 8, 1895
Civil Engineer, Waterford, Conn.

DAVIS, ARTHUR L. ... July 18, 1899
Assistant to President, American Bridge Co., 30 Church St., New York.

DAVIS, FRANK J. ... Feb. 14, 1911
Civil Engineer, Ansonia, Conn.

DAVIS, WALTER M. ... Aug. 13, 1913
Associate Member, New Haven, Conn.

DENMAN, WALTER M. ... Feb. 11, 1908
Civil Engineer, Springfield, Mass.

DePEYSTER, FREDERICK ... Sept. 3, 1891
General Manager Brainard, Schaler & Hall Quarry, Portland, Conn.

DEYO, SOLOMON LeF. ... Jan. 9, 1900
Chief Engineer New York Rapid Transit Subway Construction Co.,
New York City, N. Y.

DOERR, JOHN H. ... Feb. 11, 1913
Civil Engineer, New Haven, Conn.

DONEGAN, JAMES J. ... Feb. 14, 1912
University of Maine, Orono, Me.

DONNELLY, ALBERT J. ... Feb. 14, 1912
Civil Engineer, New Haven, Conn.

DUNHAM, WILLIAM ROBERT, JR. ... Feb. 12, 1907
Civil Engineer, Connecticut Co., New Haven, Conn.

DUNN, HERBERT L. ... Aug. 14, 1914
Civil Engineer, Woods Hole, Mass.

EASTERBROOK, FREDERICK J. .... March 30, 1900
Civil Engineer, New York City

ECKLE, JOHN N. .... Feb. 9, 1915
Civil Engineer, West Haven, Conn.

EDDY, CHARLES W. .... Jan. 9, 1900
Assistant Engineer, Waterbury Water Supply, Thomaston, Conn.

ELLSWORTH, FREDERICK H. .... March 30, 1900
Division Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.

ELTON, HERBERT C. .... Feb. 9, 1915
Civil Engineer, New Haven, Conn.

ELWELL, CHARLES C. .... Feb. 8, 1910
Member Public Utilities Commission, New Haven, Conn.

EVANS, LAFAYETTE .... Feb. 14, 1911
Second Assistant City Engineer, Bridgeport, Conn.

EVERIT, EDWARD H. .... Oct. 11, 1902
Chief Engineer S. N. E. Telephone Co., New Haven, Conn.

FARNHAM, CHARLES S. .... Feb. 9, 1904
Asst. Prof. Civil Engineering, Sheffield Scientific School, Yale University, New Haven, Conn.

FENELON, EARL T. .... Feb. 15, 1916
Civil Engineer, Bridgeport, Conn.

FERRY, CHARLES A. .... Jan. 9, 1900
Civil Engineer and Surveyor, New Haven, Conn.

FORD, FREDERICK L. .... Jan. 12, 1897
City Engineer, New Haven, Conn.

FORD, THEODORE B. .... April 20, 1901
Civil Engineer, Bridgeport, Conn.

GAGEL, EDWARD .... Jan. 9, 1900
Chief Engineer N. Y., N. H. & H. R. R. Co., New Haven, Conn.

GAILOR, CHESTER F. .... Feb. 15, 1916
Civil Engineer, New York City.

GAILOR, D. FLOYD .... Feb. 11, 1913
Civil Engineer, New Haven, Conn.

GEER, E. SELDEN, JR. .... Feb. 15, 1916
Civil Engineer, Hartford, Conn.

GEER, HENRY W. .... Aug. 12, 1915
Civil Engineer, Middletown, Conn.

GILLETTE, GEORGE W. F. .... Jan. 9, 1900
New Haven, Conn.

GLADDING, HENRY H. .... Jan. 9, 1900
Assistant City Engineer, New Haven, Conn.

GLYNN, JOHN C. .... Aug. 12, 1915
Civil Engineer, New London, Conn.

GOSS, EDWARD O. .... Nov. 29, 1890
Assistant Treasurer Scovil Mfg. Co., Waterbury, Conn.

GRAVES, EDWIN D. .... Oct. 25, 1895
Civil Engineer, Hartford, Conn.

GREEN, RICHARD K. .... Feb. 8, 1910
Civil Engineer and Surveyor, Meriden, Conn.

GREEN, ROBERT N. .... Feb. 15, 1916
Civil Engineer, Darien, Conn.

GREENWOOD, ALBERT H. .... Feb. 9, 1904
Greenwood & Noerr, Hartford, Conn.

GREGORY, J. LOUIS .... Aug. 10, 1904
Civil Engineer, Greenwich, Conn.

GRISWOLD, WALTER S. .... Feb. 14, 1912
Civil Engineer, New London, Conn.

HAMLIN, GEORGE E. .... Aug. 12, 1915
Civil Engineer, Hartford, Conn.

HAHN, FREDERICK J. .... Aug. 16, 1911
Civil Engineer, New Haven, Conn.

HALL, A. CLARK .... Jan. 8, 1901
Hartford Water Department, Bloomfield, Conn.

HALL, CHARLES ERNEST .... Feb. 12, 1907
Civil Engineer, Third Ave. Railroad Co., New York City.

HALL, GEORGE B. .... Feb. 10, 1914
Civil Engineer, Waterbury, Conn.

HALL, ROBERT B. .... Feb. 11, 1913
Civil Engineer, New Haven, Conn.

HALL, WILLIAM HENRY .... Feb. 12, 1907
City Engineer, New Britain, Conn.

HAM, GEORGE C. .... Aug. 17, 1909
Civil Engineer, Naugatuck, Conn.

HANS, ALEXANDER JOSEPH .... Feb. 12, 1907
Civil Engineer, Locust Valley, L. I.

HARRISON, IRVING WARREN .... Feb. 12, 1907
City Engineer's Office, Waterbury, Conn.

HART, JONATHAN T. .... Feb. 15, 1916
Civil Engineer, Berlin, Conn.

HARTE, CHARLES R. .... Aug. 10, 1904
Construction Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.

HASTINGS, F. B., Associate Member .... Feb. 10, 1903
B. D. Pierce Co., Bridgeport, Conn.

HAVEN, RALPH D. .... Feb. 8, 1910
Civil Engineer, East Norwalk, Conn.

HAWLEY, ARTHUR S. .... Feb. 11, 1902
C. W. Blakeslee & Sons, New Haven, Conn.

HEAD, ORRIN W. .... Feb. 15, 1916
State Highway Engineer, New Haven, Conn.

HENDERSON, JOHN T. .... July 18, 1899
Chief Engineer Conn. River Bridge and Highway District, Hartford, Conn.

HICKEY, WILLIAM F. .... Feb. 9, 1909
Care of Carnegie Steel Co., Boston, Mass.

HILL, ALBERT B. .... Jan. 9, 1900
Civil and Consulting Engineer, New Haven, Conn.

HILLHOUSE, T. CURTIS .... Feb. 14, 1912
Civil Engineer, New Haven, Conn.

HINE, FRANK E. .... April 20, 1901
Civil Engineer, Fisher's Island, N. Y.

HOHENTHAL, EMIL L. G., JR. .... Aug. 13, 1913
Civil Engineer, South Manchester, Conn.

HOSLEY, ROBERT M. .... Aug. 23, 1905
Civil Engineer, N. Y., N. H. & H. R. R. Co., New Haven, Conn.

HOWES, CYRUS P. .... Aug. 12, 1915
Civil Engineer, New Haven, Conn.

HOYT, SAMUEL W., JR. .... Feb. 9, 1904
Civil Engineer, South Norwalk, Conn.

HUBBARD, CHARLES E., Associate Member .... Aug. 17, 1909
Hartford, Conn.

HULBERT, ROBERT S. .... April, 1884
Civil Engineer, Winsted, Conn.

HULBERT, TIMOTHY ANDREWS .... Feb. 12, 1907
Technical Editor, Good Roads Magazine, New York, N. Y.

HULL, WILLIAM H. .... Aug. 11, 1914
Civil Engineer, New London, Conn.

JACKSON, J. FREDERICK .... Jan. 9, 1900
Engineer Member Conn. State Board of Health, New Haven, Conn.

JARVIS, CHARLES M. .... April, 1884
Vice President P. & F. Corbin Co., New Britain, Conn.

JAYNES, FRANK B. .... Feb. 10, 1903
Civil Engineer, Bridgeport, Conn.

JENSEN, JAMES N. .... Feb. 15, 1916
Civil Engineer, Bridgeport, Conn.

JOHNSON, GEORGE R. .... Aug. 14, 1906
Civil Engineer, West Haven, Conn.

JOHNSON, WILLIAM D. .... Aug. 14, 1900
Johnson & Burns, Inc., Architects, Hartford, Conn.

JOHNSON, WILLIAM E. .... Nov. 29, 1890
Engineer of Hartford Water Works, West Hartford, Conn.

JOHNSTONE, ALEXANDER, Associate Member .... Feb. 14, 1912
Civil Engineer, Derby, Conn.

JONES, WALTER A. .... Feb. 10, 1903
Civil Engineer, Norfolk, Va.

JONES, WALTER M., Associate Member .... Feb. 15, 1916
Civil Engineer, New London, Conn.

KEITH, HERBERT C. .... Jan. 9, 1900
Consulting Engineer, Tribune Bldg., 154 Nassau St., New York City.

KELLEY, RAYMOND E. .... Feb. 15, 1916
Civil Engineer, Hartford, Conn.

KELLOGG, HENRY J. .... April, 1884
First Assistant City Engineer, New Haven, Conn.

KELLY, CASSIUS W. .... Jan. 9, 1900
Consulting City Engineer, New Haven, Conn.

KENNEDY, DENNIS A., Associate Member .... Aug. 13, 1913
Boston, Mass.

KENT, GILBERT R. .... Aug. 16, 1910
Civil Engineer, West Haven, Conn.

KILBY, CHARLES C. .... Feb. 14, 1912
Civil Engineer, New Haven, Conn.

KIRBY, RICHARD S. .... March 30, 1900
Asst. Prof. of Mechanical Drawing, Descriptive Geometry, Sheffield
Scientific School, New Haven, Conn.

KROMER, FRANK .... Aug. 16, 1910
Civil Engineer, 1147 Fulton St., New York City.

LAFORGE, FREDERICK W. .... Jan. 13, 1885
U. S. Engineer, Fort H. G. Wright, New London, Conn.

LAMBERT, EDWARD A. .... Feb. 10, 1914
Civil Engineer, Bridgeport, Conn.

LANE, E. LEROY ....Jan. 8, 1901
Contractor, Hingham, Mass.

LANOUET, HENRY B., Associate Member ....Aug. 14, 1907
2d Assistant Engineer, N. Y., N. H. & H. R. R. Co., West Haven, Conn.

LAW, WALTER H. ....Aug. 10, 1904
Civil Engineer, Tiverton, R. I.

LAWTON, EDWIN F. ....March 30, 1900
Superintendent Hartford Electric Light Co., Hartford, Conn.

LEIGHTON, KENNETH W. ....Feb. 14, 1911
Civil Engineer, New Haven, Conn.

LEOPOLD, BENJAMIN ....Feb. 14, 1912
Civil Engineer, Waterbury, Conn.

LEWIS, ROBERT P. ....Oct. 24, 1895
Secretary and Treasurer Davidson-Lewis Metal Products Co., Inc., New York City.

LOCHRIDGE, ELBERT E. ....Aug. 23, 1905
Chief Engineer, Water Supply, Springfield, Mass.

LONGDEN, RUEL H. ....Feb. 15, 1916
Civil Engineer, Bridgeport, Conn.

LUTZ, FREDERICK W. ....Feb. 10, 1914
Civil Engineer, New Haven, Conn.

LYNCH, ALEXANDER S. ....Aug. 14, 1907
Civil Engineer, West Haven, Conn.

MAGILL, CLAUDE ....Aug. 14, 1907
Secretary Hassam Paving Co., New Haven, Conn.

MAGUIRE, JOHN P., Associate Member ....Feb. 15, 1916
Civil Engineer, New Britain, Conn.

MANVILLE, E. PERRY ....Feb. 14, 1912
Civil Engineer, East Hartford, Conn.

MARCHANT, ORSON H. ....Feb. 14, 1905
Civil Engineer, New Haven, Conn.

McCARTHY, EDWARD A. ....Feb. 15, 1916
Civil Engineer, New Britain, Conn.

McCLUSKY, CHARLES A. ....Aug. 13, 1913
Civil Engineer, New Haven, Conn.

McCONNELL, GEORGE B. ....Feb. 9, 1909
Civil Engineer, Waterbury, Conn.

McDONALD, CHARLES ....Feb. 14, 1912
Civil Engineer, Waterbury, Conn.

McDONOUGH, FRANK T. ....Feb. 10, 1914
Civil Engineer, New Haven, Conn.

McELROY, JAMES A. ....Feb. 9, 1909
Civil Engineer, Bridgeport, Conn.

McKAIG, T. P. ....Aug. 11, 1914
Civil Engineer, Hartford, Conn.

McKENZIE, SAMUEL H. ....Feb. 9, 1915
Civil Engineer, Southington, Conn.

McKENZIE, THOMAS ....Feb. 12, 1907
Superintendent of Water Works and Town Engineer, Westerly, R. I.

McKENZIE, WILLIAM A. ....Aug. 11, 1914
Civil Engineer, Wallingford, Conn.

McKNIGHT, JOHN T. ....May 31, 1893
City Engineer, Rockville. Residence, Ellington, Conn.

McLAUGHLIN, FRANK .... Feb. 15, 1916
Civil Engineer, Bridgeport, Conn.

McLEAN, GEORGE H. .... Feb. 9, 1904
Civil Engineer, New Haven, Conn.

MEEKER, REGINALD C. .... Feb. 9, 1915
Civil Engineer, Bridgeport, Conn.

MERRELS, CHARLES W. .... Jan. 9, 1900
City Engineer's Office, New Haven, Conn.

MERRIMAN, ERNEST .... Feb. 11, 1913
Bridge Department, N. Y., N. H. & H. R. R., New Haven, Conn.

MERRITT, MALCOLM .... Aug. 12, 1908
Daly & Merritt, Contracting Engineers, Port Chester, N. Y.

MILLER, CLYDE A. .... Feb. 10, 1914
Civil Engineer, Torrington, Conn.

MILLER, RODNEY B. .... Feb. 9, 1909
Civil Engineer, New Britain, Conn.

MILLER, WILLIAM H. .... Aug. 12, 1908
Civil Engineer, Middlebury, Conn.

MINOR, EDWARD E. .... Feb. 9, 1904
Superintendent New Haven Water Co., New Haven, Conn.

MINOR, JUDSON M. .... Feb. 13, 1906
Civil Engineer, New Haven, Conn.

MINOR, PIERPONT L. .... Feb. 11, 1913
Civil Engineer, Greenwich, Conn.

MINOR, SHELDON E. .... Sept. 25, 1886
Civil Engineer, Greenwich, Conn.

MITCHELL, ROBERT E. .... Jan. 9, 1900
City Engineer, Willimantic, Conn.

MOONEY, JAMES F. .... Feb. 9, 1915
Civil Engineer, Thompsonville, Conn.

MOORE, WM. HARLEY .... Jan. 9, 1900
Engineer of Bridges, N. Y., N. H. & H. R. R., New Haven, Conn.

MORTON, WALTER S. .... Aug. 10, 1904
Morton & Burritt, Civil Engineers, New York, N. Y.

MOSS, ERNEST B. .... April 20, 1901
Civil Engineer, H. Wales Lines Co., Meriden, Conn.

MURPHY, HAROLD T. .... Feb. 9, 1904
Civil Engineer and Surveyor, Springfield, Mass.

MURPHY, JOHN P. .... July 18, 1899
City Engineer's Office, Hartford, Conn.

MYLCHREEST, GEORGE L. .... Feb. 15, 1916
Civil Engineer, Hartford, Conn.

NASH, PAUL .... Jan. 9, 1900
Superintendent Public Works, Stamford, Conn.

NETTLETON, EDWARD S. .... Feb. 11, 1913
City Engineer's Office, New Haven, Conn.

NEWLANDS, JAMES A. .... Feb. 15, 1916
Henry A. Souther Co., Hartford, Conn.

NICHOLS, CHARLES H. .... Jan. 8, 1901
Consulting Engineer and Engineer of Shell Fish Commission,
New Haven, Conn.

NICKERSON, CLARENCE H. .... Feb. 10, 1914
Civil Engineer, Torrington, Conn.

NOERR, ROBERT COLLYER Greenwood & Noerr, Hartford, Conn.	Feb. 12, 1907
NORD, CHARLES L. Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.	Feb. 8, 1910
O'CONNOR, DON, Associate Member D. F. Keenan, Hartford, Conn.	Feb. 9, 1904
OLMSTED, C. HENRY Civil Engineer and Surveyor, East Hartford, Conn.	July 18, 1899
OLSEN, JOHN Civil Engineer, 82 Church St., New Haven, Conn.	Feb. 12, 1907
ORROK, GEORGE A. Civil Engineer, Lee, Mass.	Feb. 9, 1909
OSBORNE, H. SANFORD Civil Engineer, Redding Ridge, Conn.	Feb. 10, 1914
PALMER, SHEPARD B. Chandler & Palmer, Norwich, Conn.	Jan. 8, 1895
PALMER, WILLIAM B. Civil Engineer and Surveyor, Bridgeport, Conn.	Jan. 13, 1885
PARDEE, WILLIAM S., Associate Member New Haven, Conn.	Aug. 10, 1904
PARKER, GEORGE A. Superintendent of Keney Park, Hartford, Conn.	July 18, 1899
PARSONS, HAROLD A. Civil Engineer, Stamford, Conn.	Aug. 14, 1900
PATIENCE, FREDERICK G. Civil Engineer, Hartford, Conn.	Feb. 9, 1909
PATTERSON, CHARLES A. Civil Engineer, Torrington, Conn.	Feb. 11, 1913
PATTON, ARTHUR J. Land Surveyor, Waterbury, Conn.	Sept. 12, 1889
PAYNE, MORRIS B. Civil Engineer, New London, Conn.	Feb. 14, 1911
PECK, CLIFFORD A. Civil Engineer, New London, Conn.	Aug. 12, 1915
PECK, ERMON M. Civil Engineer, Hartford, Conn.	Jan. 8, 1895
PECK, LEON F. Superintendent of Streets, Hartford, Conn.	Oct. 11, 1902
PENFIELD, GEORGE W. Civil Engineer, New Hartford, Conn.	Jan. 8, 1901
PERRY, GEORGE W. Civil Engineer, Putnam, Conn.	Aug. 11, 1914
PHELPS, JAMES W. Landscape Architect, Bolton, Conn.	Oct. 11, 1902
PHELPS, JEFFREY O. Civil Engineer, Hartford, Conn.	Aug. 12, 1915
PIERCE, BRADFORD D., JR. Civil Engineer, Bridgeport, Conn.	Aug. 23, 1905
PIERSON, STEPHEN C. Civil Engineer and Surveyor, Meriden, Conn.	Jan. 13, 1885
PIKE, WILLIAM K. Civil Engineer, Danielson, Conn.	Feb. 9, 1904
PORISS, SOLOMON C. Civil Engineer, Hartford, Conn.	Aug. 13, 1913

PORTER, HOWARD S. .... Feb. 8, 1910
Civil Engineer, Hartford, Conn.

PRENTIS, HUGH L. .... Feb. 10, 1914
Civil Engineer, New London, Conn.

PRESTON, CHARLES HENRY, JR. .... Feb. 12, 1907
Civil Engineer and Surveyor, Waterbury, Conn.

PUNDERFORD, JOHN K. .... Jan. 9, 1900
Gen. Manager Connecticut Co., New Haven, Conn.

QUAY, JOHN P. .... [illegible]
Civil Engineer, New London, Conn.

RANDLE, JONATHAN S. .... Feb. 14, 1911
Civil Engineer, New Haven, Conn.

RAPUANO, JOSEPH H. .... Aug. [illegible]
Civil Engineer, New Haven, Conn.

RASK, PETER K. .... Feb. [illegible]
Civil Engineer, Hartford, Conn.

REICHGOTT, DAVID .... Feb. 11, 1913
City Engineer's Office, New Haven, Conn.

REYNOLDS, WM. B. .... Aug. 14. 1900
Land Surveyor, Waterbury, Conn.

RICE, ARTHUR W. .... April, 1884
Civil Engineer, New Britain, Conn.

RICH, RICHARD H. .... Aug 11, 1914
Civil Engineer, New Haven, Conn.

RICHARDS, HOWARD S. .... Aug. 11, 1914
Civil Engineer, New London, Conn.

RICHARDS, WALTER H. .... March 30, 1900
Engineer of Water and Sewer Department, New London, Conn.

ROBINSON, LEONI W. .... Feb. 14, 1905
Architect, New Haven, Conn.

ROBINSON, SEYMOUR N. .... Feb. 9, 1904
Civil Engineer, Hartford, Conn.

ROEBUCK, ALFRED, JR., Associate Member .... Aug. 13, 1913
Meriden, Conn.

ROGERS, CHARLES EDWIN .... Feb. 12, 1907
Prof. Civil Engineering, Trinity College, Hartford, Conn.

ROSS, ROBERT J. .... Feb. 9, 1915
Civil Engineer, Hartford, Conn.

RUFF, JOHN S. .... Feb. 12, 1907
Engineering Department, N. Y., N. H. & H. R. R., New Haven, Conn.

RYDER, ELY M. T. .... Jan. 9, 1900
Civil Engineer, Yonkers, N. Y.

SAGE, GEORGE H. .... Jan. 8, 1895
Vice President Berlin Construction Co., Berlin, Conn.

SANDERS, JOHN .... Feb 8, 1910
Electrical Engineer, Danbury, Conn

SAUNDERS, RICHARD L. .... Feb. 9. 1909
State Highway Commissioner's Office, Hartford, Conn.

SAVILLE, CALEB M. .... [illegible]
Chief Engineer, Hartford Water Works, Hartford, Conn.

SCHILLING, ALBERT H. .... Aug. 14, 1906
Berlin Construction Co., New Britain, Conn.

[illegible] EDWIN W. .... [illegible]
Civil Engineer, Bridgeport, Conn.

SCOTT, THOMAS A. ....Aug. 11, 1914
Contracting Engineer, New London, Conn.

SEARS, SELDON P. ....Feb. 14, 1912
Civil Engineer, New Hartford, Conn.

SELLARS, PHILIP ....Feb. 9, 1904
Architect, New Haven, Conn.

SHARP, WILLIAM H. ....Aug. 11, 1914
Civil Engineer, Middletown, Conn.

SHAUGHNESSY, JAMES F. ....Feb. 11, 1902
Care of Board of Water Commission, New Hartford, Conn.

SHELDON, PAUL ....Feb. 12, 1907
Ford, Buck & Sheldon, Civil Engineers, Hartford, Conn.

SHOOK, BURTON ....Feb. 15, 1916
Civil Engineer, Bridgeport, Conn.

SIBLEY, CHARLES A. ....Feb. 11, 1908
Contracting Engineer, New Haven, Conn.

SMEAD, RALPH A. ....Feb. 15, 1916
Civil Engineer, Hartford, Conn.

SMITH, FRINK M. ....Aug. 23, 1905
Civil Engineer, Waterbury, Conn.

SMITH, GEORGE E. ....Feb. 10, 1903
Civil Engineer, Hartford, Conn.

SMITH, WILLIAM G. ....April, 1884
Civil Engineer and Surveyor, Waterbury, Conn.

SNELL, EDWARD B. ....Feb. 13, 1906
Civil Engineer, New Haven, Conn.

SOEHRENS, JOHN H. ....Aug. 10, 1904
Assistant Engineer, N. Y., N. H. & H. R. R. Co., New London, Conn.

SPENCER, NORMAN C. ....Jan. 8, 1901
Spencer & Washburn, Civil Engineers, Hartford, Conn.

SPENCER, PAUL B. ....Feb. 9, 1915
Civil Engineer, New London, Conn.

SPENCER, WALTER T. ....Jan. 9, 1900
Civil Engineer, N. Y., N. H. & H. R. R. Co., Taunton, Mass.

SPERRY, A. WILLIAM ....Jan. 9, 1900
Contracting Engineer, New Haven, Conn.

SPRAGUE, JOHN V., JR. ....Feb. 11, 1913
City Engineer's Office, New Haven, Conn.

STARK, MELVIN E. ....Aug. 11, 1914
Civil Engineer, Stratford, Conn.

STARKWEATHER, WALTER H. ....Feb. 11, 1913
Civil Engineer, New Haven, Conn.

STEELMAN, MARTIN S. ....Feb. 15, 1916
Civil Engineer, Hartford, Conn.

STERLING, PAUL ....Oct. 11, 1902
Civil Engineer, N. Y., N. H. & H. R. R. Co., Stamford, Conn.

STEVENS, ROBERT W. ....Feb. 8, 1910
Division Engineer, Hartford County, Hartford, Conn.

STEWART, ALANSON E. ....Feb. 10, 1914
Civil Engineer, Port Chester, N. Y.

STILES, EDGAR H. ....Oct. 11, 1902
Civil Engineer, New Haven, Conn.

STODDARD, RAYMOND FRENCH ....Jan. 9, 1900
Consulting Engineer, Bridgeport, Conn.

STONE, EDWARD M. .... July 18, 1899
Civil Engineer and Surveyor, Hartford, Conn.

STORRS, HENRY W. .... Aug. 23, 1905
Civil Engineer, Berlin Construction Co., Berlin, Conn.

STORY, I. FRANKLIN .... Aug. 21, 1912
Civil Engineer, Waterbury, Conn.

STORY, ISAAC M. .... Feb. 13, 1906
Civil Engineer, N. Y., N. H. & H. R. R., New Haven, Conn.

SULLIVAN, JOHN M. .... Aug. 10, 1904
Assistant Engineer of Construction, N. Y., N. H. & H. R. R.,
New Haven, Conn.

SUNDERLIN, GEORGE W., Associate Member .... Feb. 14, 1911
Toole & Sunderlin, Bridgeport, Conn.

TAYLOR, CHARLES F. .... Aug. 12, 1908
Civil Engineer, Hartford, Conn.

TAYLOR, GEORGE B. .... Feb. 9, 1915
Civil Engineer, New Britain, Conn.

TAYLOR, WILLIAM T. .... Feb. 9, 1904
Civil Engineer, Hartford, Conn.

TERRY, ALFRED H. .... Feb. 11, 1900
City Engineer, Bridgeport, Conn.

TERRY, JAMES .... Feb. 8, 1910
Secretary Terry Co., Hartford, Conn.

THAYER, MERWIN A. .... Feb. 14, 1912
Civil Engineer, Winsted, Conn.

THAYER, RAYMOND E. .... Feb. 14, 1912
Civil Engineer, New London, Conn.

THOMAS, JAMES B. .... Jan. 9, 1900
Bishop Ladder Co., Hartford, Conn.

TODD, JAMES W., Associate Member .... Aug. 16, 1910
546 State St., New Haven, Conn.

TONER, JAMES A. .... Aug. 23, 1905
City Engineer's Office, Meriden, Conn.

TOOLE, JOHN F., Associate Member .... Feb. 14, 1911
Toole & Sunderlin, Bridgeport, Conn.

TRACY, JOHN C. .... Jan. 9, 1900
Professor of Civil Engineering, Yale University, New Haven, Conn.

TRAVIS, FRANK M. .... Feb. 9, 1915
Civil Engineer, Torrington, Conn.

TROWBRIDGE, F. J. .... Feb. 14, 1912
Civil Engineer, Waterbury, Conn.

TRUESDELL, WALTER E. .... June 11, 1898
Civil Engineer, 5 Beekman St., New York City.

TRUMBULL, JOHN F. .... Aug. 10, 1904
Engineer, Public Utilities Commission, New Haven, Conn.

TUCKER, JOHN J. .... Feb. 9, 1915
Civil Engineer, New Haven, Conn.

TURNER, ALBERT M. .... Aug. 10, 1905
Civil Engineer, State Park Commission, Northfield, Conn.

ULRICH, WILLIAM L. .... Aug. 13, 1913
Civil Engineer, South Manchester, Conn.

UNKELBACH, MAX J. .... Jan. 9, 1900
Architect and Civil Engineer, New Britain, Conn.

VAUGHN, EDWARD J.	Civil Engineer, Hartford, Conn.	Feb. 15, 1916
VERRILL, GEORGE E.	U. S. Assistant Engineer, New Haven, Conn.	Feb. 11, 1902
VORCE, CLARENCE B.	Civil Engineer, Farmington, Conn.	Jan. 10, 1899
WADHAMS, JOSEPH P.	Civil Engineer, New Haven, Conn.	Feb. 9, 1904
WADSWORTH, A. R.	Civil Engineer and Surveyor, Farmington, Conn.	Oct. 27, 1886
WALLER, WILLIAM E.	Civil Engineer, Bridgeport, Conn.	Feb. 9, 1915
WARDWELL, FREDERICK S.	Contracting Engineer, Stamford, Conn.	Feb. 9, 1904
WASHBURN, ALBERT L.	City Engineer's Office, Hartford, Conn.	Jan. 10, 1899
WATERMAN, CHARLES P.	Civil Engineer, Grozier Co., Hartford, Conn.	Feb. 11, 1908
WATROUS, KENNETH	Civil Engineer, Groton, Conn.	Feb. 14, 1911
WATSON, EDMUND B.	Civil Engineer, Danbury, Conn.	Aug. 11, 1914
WATTERS, GEORGE E.	Civil Engineer, New London, Conn.	Feb. 14, 1911
WELLS, ALDEN	Civil Engineer, Hartford, Conn.	Feb. 15, 1916
WELTON, NELSON J.	Civil and Hydraulic Engineer, Waterbury, Conn.	April, 1884
WHEELER, CHARLES A.	Prof. of Mathematics, Conn. Agricultural College, Storrs, Conn.	Jan. 8, 1901
WHITE, HOWARD E.	New Haven Gas Light Co., New Haven, Conn.	Feb. 9, 1904
WHITNEY, ELI	President New Haven Water Co., New Haven, Conn.	March 30, 1900
WHITON, FRANK W., Associate Member	Architect, Hartford, Conn.	Feb. 14, 1905
WHITTAKER, RAYMOND B., Associate Member	Civil Engineer, New York City.	Feb. 15, 1916
WHITTEMORE, JOSEPH B.	Civil Engineer, Norwich, Conn.	Feb. 9, 1915
WIGGIN, ERNEST W.	Consulting Engineer, New Haven, Conn.	March 30, 1900
WIGHTMAN, HERBERT B.	Civil Engineer, Norwich, Conn.	Aug. 16, 1910
WILLIAMS, HARRY T.	Civil Engineer, Waterbury, Conn.	Aug. 12, 1915
WILLIAMS, JOSEPH D.	Civil Engineer, New Britain, Conn.	Feb. 15, 1916
WILLIAMS, PHILIP K.	Assistant Superintendent J. B. Williams Co., Glastonbury, Conn.	Aug. 14, 1906
WILLISTON, WALTER	Civil Engineer, Torrington, Conn.	Feb. 14, 1911

WILSON, [illegible] .... [illegible]
Road Master, Conn. Co., New Haven, Conn.

WOLCOTT, HENRY A. .... July 18, 1899
Mechanical and Civil Engineer, Hartford, Conn.

WOODS, JOHN I. .... Feb. [illegible], 1914
Civil Engineer, Baltic, Conn.

WORTHEN, ALBERT LOUIS .... Feb. [illegible]
City Engineer, New Haven, Conn.

WRIGHT, CLAUDE W. .... Feb. 14, 1912
Civil Engineer, F. T. Ley Co., Springfield, Mass.

WRIGHT, FRANK W. .... Aug. 12, 1908
Civil Engineer, New Haven, Conn.

ALPHABETICAL LIST OF ADVERTISERS

Name	Business	Page
American Pipe and Construction Co., The	Iron Pipe and Contracting	15
American Sewer Pipe Co., The	Vitrified Sewer Pipe	42
Balf Co., The Edward	Teaming and Contracting	40
Barber Asphalt Paving Co., The	Pavements	24
Barbour, Stockwell Co., The	Rails, Switches and Castings	33
Barrett Co., The	Roofing and Pitch	1
Bausch & Lomb Optical Co., The	Engineering Instruments	16
Berger, C. L. & Sons	Engineering Instruments	40
Berlin Construction Co., The	Steel Structures	(back cover)
Blakeslee, C. W. & Sons	Contractors. Crushed Stone	10
Bond Co., The Harold L.	Contractors' Supplies	31
Brodie Co., The William H.	Fire Protection	7
Buffalo Steam Roller Co., The	Road Rollers, etc.	8
Cardinell-Vincent Co., The	Drawing Materials	19
Chicago Bridge & Iron Works, The	Metal Tanks	29
Christiano, Joseph	Contractor	28
Connecticut Hassam Pavement Co., The	Pavements	5
Connecticut Quarries Co., The	Trap Rock	17
Daly & Merritt	Contractors	21
Detroit Graphite Co., The	Paint	38
Eastern Clay Goods Co., The	Vitrified Sewer Pipe	20
Edson Manufacturing Co., The	Pumps	12
French & Co., Samuel H.	Cement	40
Fuller, George W.	Hydraulic and Sanitary Engineer	39
Giant Portland Cement Co., The	Cement	20
Grant, C. L., Inc.	Borings	3
Gurley, W. & L. E.	Engineering Instruments	30
Hansen, John	Contractor	22
Jordan Co., The	Cement, Bluestone, Sewer Pipe, etc.	11
Knickerbocker Portland Cement Co., The	Cement	13
Keith, Herbert C.	Consulting Engineer	19
Keuffel & Esser Co., The	Engineering Instruments and Supplies	9
Koehring Machine Co., The	Concrete Mixers	32
Kolesch & Co.	Engineering Instruments	19
Lathrop & Shea Co., The	Contractors	35
Lawrence Portland Cement Co., The	Cement	11
Ley & Co., Inc., Fred T.	Contractors	18
Lines Co., The H. Wales	Sewer Pipe, Stone and Cement	26
Ludlow Valve Co., The	Valves	2
Lufkin Rule Co., The	Tapes and Rules	39
Lupton's Sons Co., The David	Metal Sashes and Doors	36
Metcalf & Eddy	Consulting Engineers	3
National Order of Sign Removers, The	Highway Improvement	39
New Haven Trap Rock Co., The	Trap Rock	14
Pacific Flush-Tank Co., The	Miller Automatic Siphon	41
Rockport Granite Co., The	Granite	4
Scott Co., Inc., The T. A.	Marine Construction, etc.	(inside back cover)
Sessions Foundry Co., The	Sewer Castings, etc.	2
Sperry Engineering Co., The	Contracting Engineers	30
St. Marys Sewer Pipe Co., The	Vitrified Sewer Pipe	34
Standard Oil Co. of New York, The	Road Oil	25
Stoddard Engraving Co., The	Engravers	9
Strauss Bascule Bridge Co., The	Bridges	6
Studebaker	Street Sprinkling and Oiling Wagons, etc.	10
Tuttle, Morehouse & Taylor Co., The	Printers and Publishers	27
United States Wood Preserving Co., The	Pavements	(inside front cover)
Wardwell, Frederick S.	Engineer and Contractor	23
Warner-Miller Co., The	Cement, Bluestone, Sewer Pipe, etc.	37
Warren Foundry & Machine Co., The	Cast Iron Pipe	17

CLASSIFIED LIST OF ADVERTISERS

ARTESIAN WELLS.

C. L. Grant, Inc., Hartford, Conn.	3

ASPHALT.

The Barber Asphalt Paving Co., Philadelphia, Pa.	24

AUTOMOBILES.

Studebaker, South Bend, Ind.	1

BORINGS.

C. L. Grant, Inc., Hartford, Conn.	3
The T. A. Scott Co., Inc., New London, Conn.	(inside back cover)

BRICK.

The Warner-Miller Co., New Haven, Conn.	37

BRIDGES.

The Berlin Construction Co., Berlin, Conn.	(back cover)
The Chicago Bridge & Iron Works, Chicago, Ill.	29
The Strauss Bascule Bridge Co., Chicago, Ill.	6

CAST IRON PIPE.

The American Pipe and Construction Co., Philadelphia, Pa.	15
The Warren Foundry & Machine Co., Phillipsburg, N. J.	17

CEMENT.

The Warner-Miller Co., New Haven, Conn.	37
The H. Wales Lines Co., Meriden, Conn.	26
Samuel H. French & Co., Philadelphia, Pa.	40
The Lawrence Cement Co., New York, N. Y.	11
The Jordan Co., New Haven, Conn.	11
The Giant Portland Cement Co., New York, N. Y.	20
The Knickerbocker Portland Cement Co., New York, N. Y.	13

CONCRETE.

The Lathrop & Shea Co., New Haven, Conn.	35
The Sperry Engineering Co., New Haven, Conn.	30
Fred. T. Ley & Co., Inc., Springfield, Mass.	18
Frederick S. Wardwell, Stamford, Conn.	[illegible]
C. W. Blakeslee & Sons, New Haven, Conn.	10
The T. A. Scott Co., Inc., New London, Conn.	(inside back cover)

CONCRETE MIXERS.

The Koehring Machine Co., Milwaukee, Wis.	32

CONSULTING ENGINEERS.

Herbert C. Keith, New York, N. Y.	19
George W. Fuller, New York, N. Y.	39
Metcalf & Eddy, Boston, Mass.	3

CONTRACTORS AND CONTRACTING ENGINEERS.

The American Pipe and Construction Co., Philadelphia, Pa.	15
The Edward Balf Co., Hartford, Conn.	4
The H. Wales Lines Co., Meriden, Conn.	26
The Lathrop & Shea Co., New Haven, Conn.	35
The T. A. Scott Co., Inc., New London, Conn.	(inside back cover)
The Sperry Engineering Co., New Haven, Conn.	30
Fred T. Ley & Co., Inc., Springfield, Mass.	18
Frederick S. Wardwell, Stamford, Conn.	[illegible]
Joseph Christiano, Greenwich, Conn.	28
Daly & Merritt, Port Chester, N. Y.	21
[illegible] Hansen, Greenwich, Conn.	[illegible]
C. W. Blakeslee & Sons, New Haven, Conn.	10
The Connecticut Hassam Pavement Co., New Haven, Conn.	[illegible]

CONTRACTORS' SUPPLIES.

The Harold L. Bond Co., Boston, Mass.	31

CRUSHED STONE.

The Connecticut Quarries Co., New Haven, Conn.	17
C. W. Blakeslee & Sons, New Haven, Conn.	10
The Edward Balf Co., Hartford, Conn.	40
The New Haven Trap Rock Co., New Haven, Conn.	14

DRAWING MATERIALS.

W. & L. E. Gurley, Troy, N. Y.	30
The Cardinell-Vincent Co., San Francisco, Cal.	19
The Keuffel & Esser Co., Hoboken, N. J., and New York, N. Y.	9

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W. & L. E. Gurley, Troy, N. Y.	30
Kolesch & Co., New York, N. Y.	19
The Lufkin Rule Co., Saginaw, Mich.	39
The Bausch & Lomb Optical Co., Rochester, N. Y.	16
The Keuffel & Esser Co., Hoboken, N. J., and New York, N. Y.	9

ENGINES AND BOILERS.

The Harold L. Bond Co., Boston, Mass.	31

ENGRAVING.

The Stoddard Engraving Co., New Haven, Conn.	9

EXPLOSIVES.

The Harold L. Bond Co., Boston, Mass.	31

FIREPROOFING AND FIRE PROTECTION.

The William H. Brodie Co., New York, N. Y.	7
The David Lupton's Sons Co., New York, N. Y.	36

FLUSH TANKS.

The Pacific Flush-Tank Co., Chicago, Ill.	41

GRANITE.

The Rockport Granite Co., Rockport, Mass.	4

HIGHWAY IMPROVEMENT.

The National Order of Sign Removers, New Haven, Conn.	39

IMHOFF TANKS.

The Pacific Flush-Tank Co., Chicago, Ill.	41

IRON, STEEL, ETC.

The Berlin Construction Company, Berlin, Conn.	(back cover)
The Chicago Bridge & Iron Works, Chicago, Ill.	29

LIFT BRIDGES.

The Strauss Bascule Bridge Co., Chicago, Ill.	6

MARINE CONSTRUCTION.

The T. A. Scott Co., Inc., New London, Conn.	(inside back cover)
Frederick S. Wardwell, Stamford, Conn.	23

METAL SASHES AND DOORS.

The William H. Brodie Co., New York, N. Y.	7
The David Lupton's Sons Co., New York, N. Y.	36

PAINT.

The Detroit Graphite Co., Detroit, Mich.	38

PAVEMENTS.

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The Barrett Co., New York, N. Y.	1
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C. W. Blakeslee & Sons, New Haven, Conn.	10
The Edward Balf Co., Hartford, Conn.	40
The Connecticut Hassam Pavement Co., New Haven, Conn	5

PILING.

The H. Wales Lines Co., Meriden, Conn. 26
The T. A. Scott Co., Inc., New London, Conn. .... (inside back cover)
Fred. T. Ley & Co., Inc., Springfield, Mass. 18
Frederick S. Wardwell, Stamford, Conn. 21
C. W. Blakeslee & Sons, New Haven, Conn. 10
The Lathrop & Shea Co., New Haven, Conn. 35

PRINTERS.

The Tuttle, Morehouse & Taylor Co., New Haven, Conn. 27

PUMPS AND PUMPING MACHINERY.

The Edson Manufacturing Co., Boston, Mass. 12
The Harold L. Bond Co., Boston, Mass. 31
C. L. Grant, Inc., Hartford, Conn 3

RAILS, SWITCHES, ETC.

The Barbour, Stockwell Co., Cambridge, Mass. 33

ROAD OILS, ASPHALT AND PAVING PITCH.

The Standard Oil Co. of New York 25
The Barrett Co., New York, N. Y. 1
The Barber Asphalt Paving Co., Philadelphia, Pa. 24

ROAD ROLLERS.

The Buffalo Steam Roller Co., Buffalo, N. Y. 8

ROOFING.

The Barrett Co., New York, N. Y. 1

SANITARY ENGINEERS.

George W. Fuller, New York, N. Y. 39
Metcalf & Eddy, Boston, Mass. 3

SEWER CASTINGS.

The Sessions Foundry Co., Bristol, Conn. 2
The Barbour, Stockwell Co., Cambridge, Mass. 33

SEWER PIPE.

The St. Marys Sewer Pipe Co., St. Marys, Pa. 34
The H. Wales Lines Co., Meriden, Conn. 26
The Warner-Miller Co., New Haven, Conn. 37
The Jordan Co., New Haven, Conn. 11
The American Sewer Pipe Co., Akron, O. 42
The Eastern Clay Goods Co., Boston, Mass 20

SKYLIGHTS AND VENTILATION.

The David Lupton's Sons Co., New York, N. Y. 36

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The William H. Brodie Co., New York, N. Y. 7
The David Lupton's Sons Co., New York, N. Y. 36

STEEL REINFORCING BARS, ETC.

The Warner-Miller Co., New Haven, Conn. 37
The Jordan Co., New Haven, Conn. 11

STEEL STRUCTURES.

The Berlin Construction Co., Berlin, Conn. .... (back cover)
The Chicago Bridge and Iron Works, Chicago, Ill. 29

STONE.

The Connecticut Quarries Co., New Haven, Conn. 17
The Warner-Miller Co., New Haven, Conn. 37
The H. Wales Lines Co., Meriden, Conn. 26
The Jordan Co., New Haven, Conn. 11
The Rockport Granite Co., Rockport, Mass. 4
C. W. Blakeslee & Sons, New Haven, Conn. 10
The New Haven Trap Rock Co., New Haven, Conn. 14

STREET SPRINKLING, CLEANING AND OILING APPARATUS.
Studebaker, South Bend, Ind 10

SUBMARINE WORK.
The T. A. Scott Co., Inc., New London, Conn. .... (inside back cover)
Frederick S. Wardwell, Stamford, Conn 23

TANKS (STEEL).
The Chicago Bridge & Iron Works, Chicago, Ill. 29

TAPES.
C. L. Berger & Sons, Boston, Mass. 40
W. & L. E. Gurley, Troy, N. Y. 30
Kolesch & Co., New York, N. Y. 19
The Lufkin Rule Co., Saginaw, Mich. 39
The Keuffel & Esser Co., Hoboken, N. J., and New York, N. Y. 9

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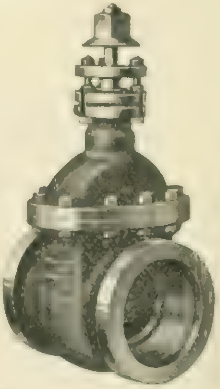

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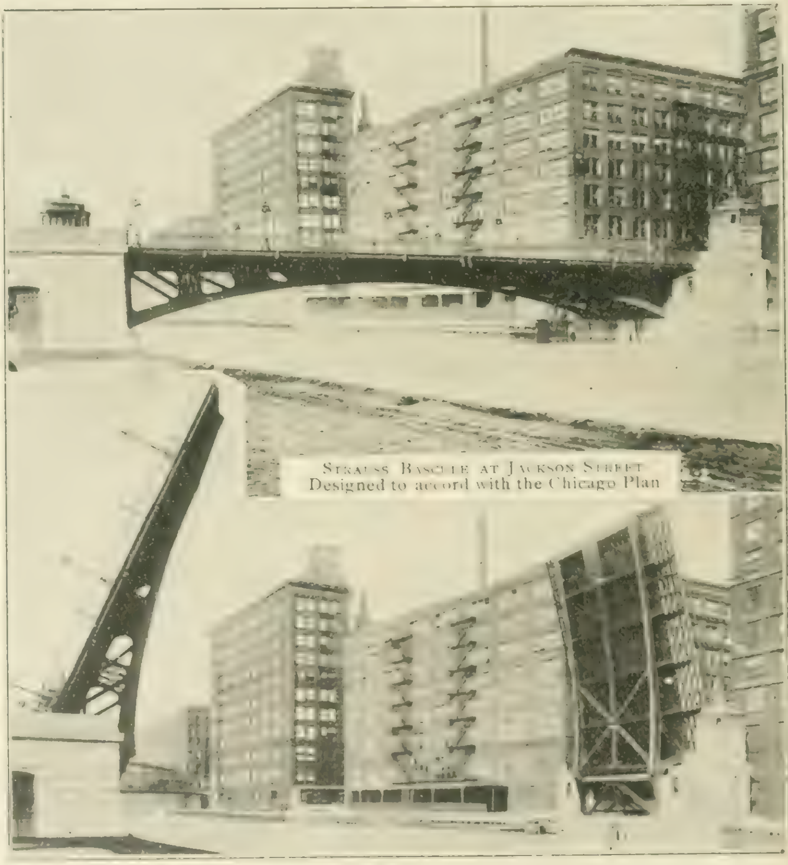

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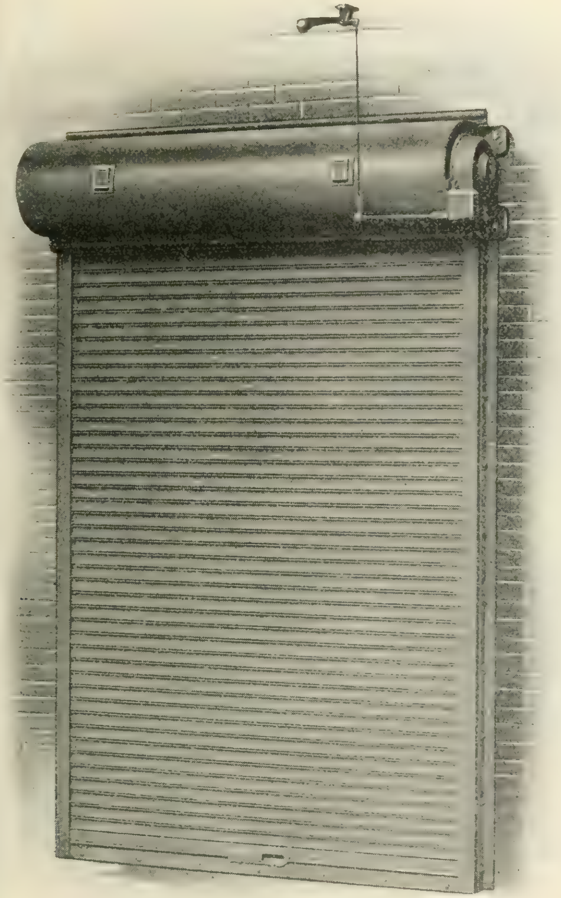

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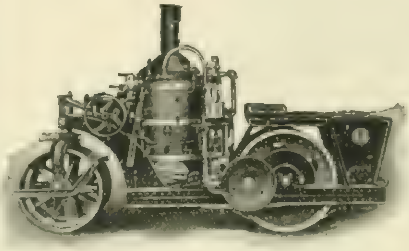

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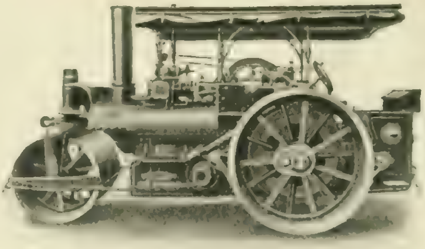

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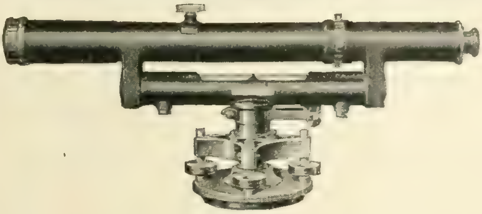

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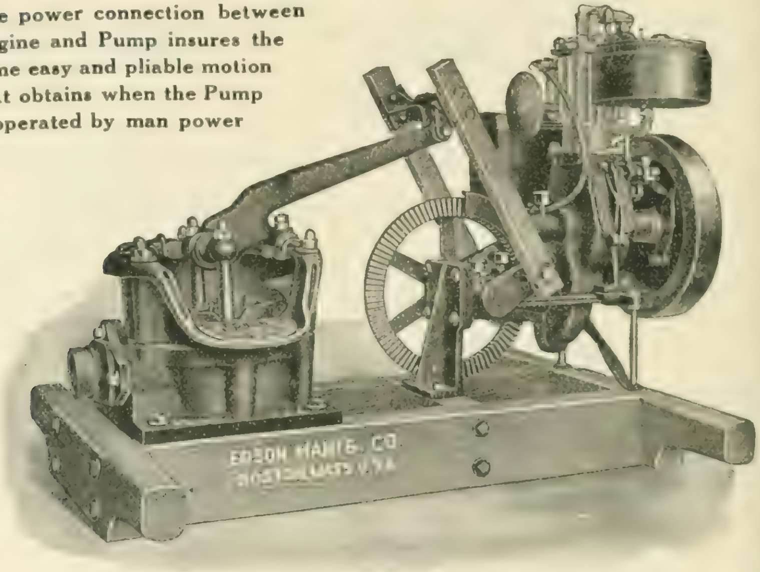

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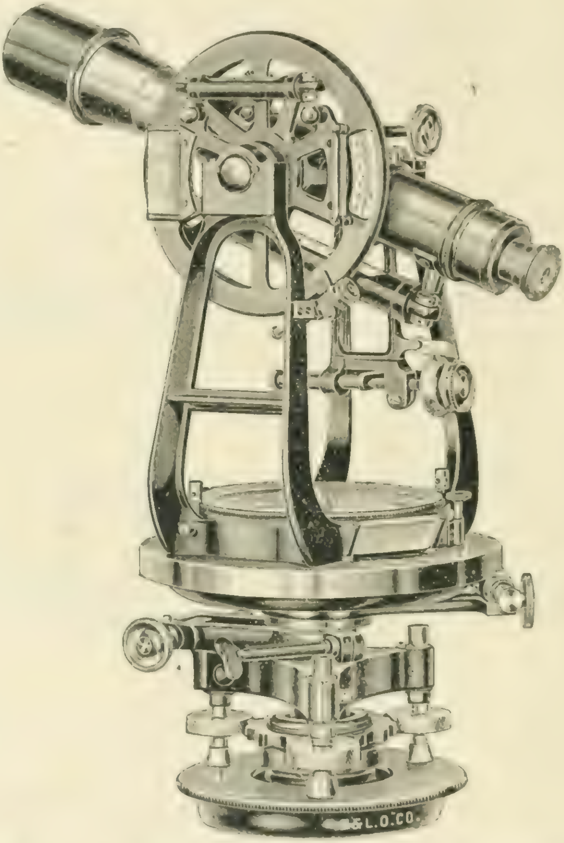

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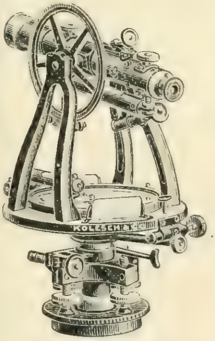

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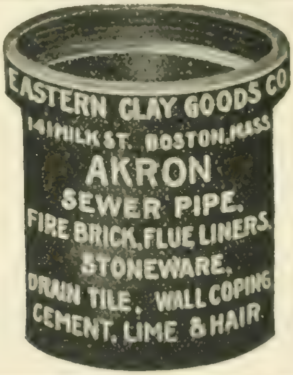

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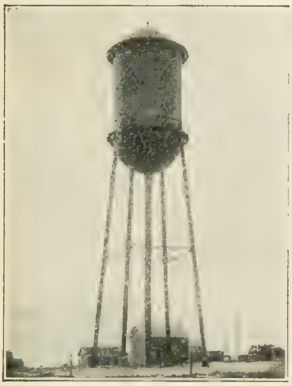

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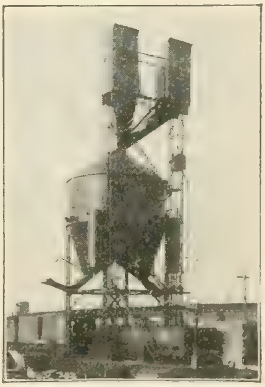

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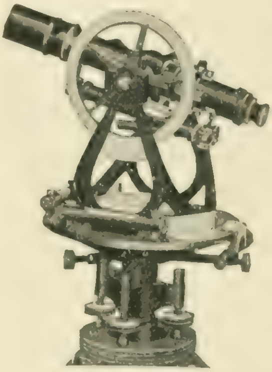

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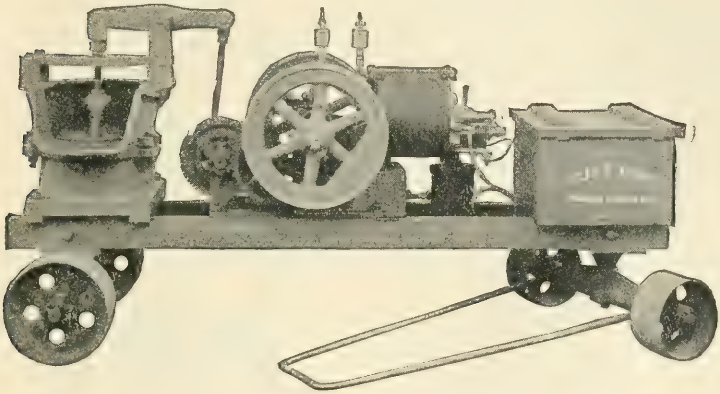

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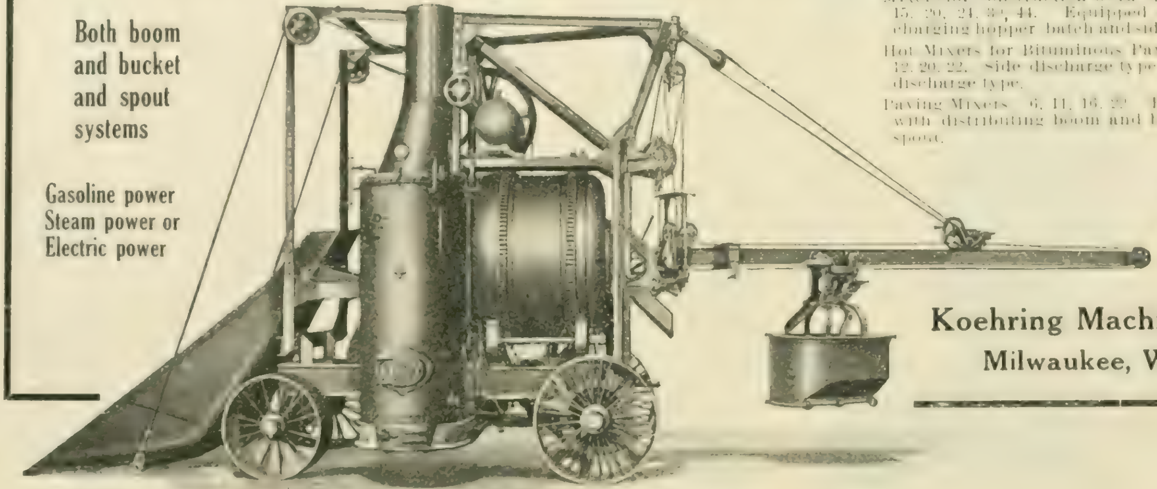

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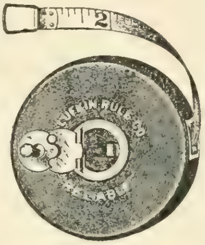

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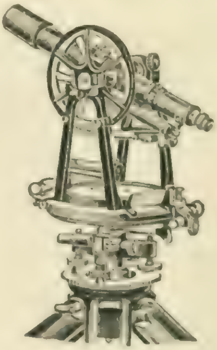

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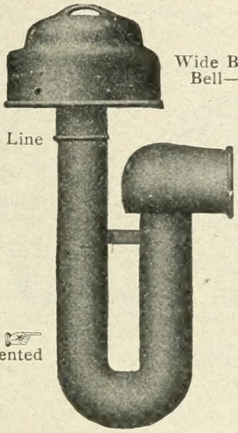
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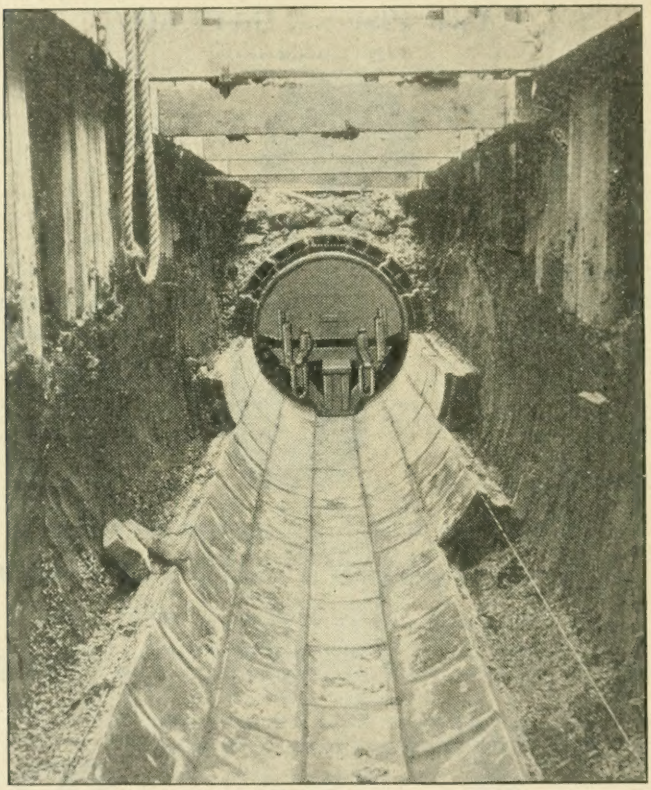

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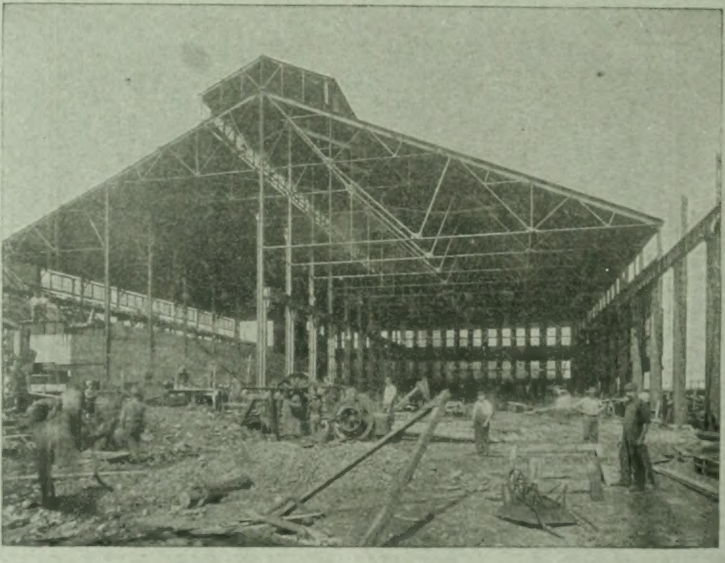

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